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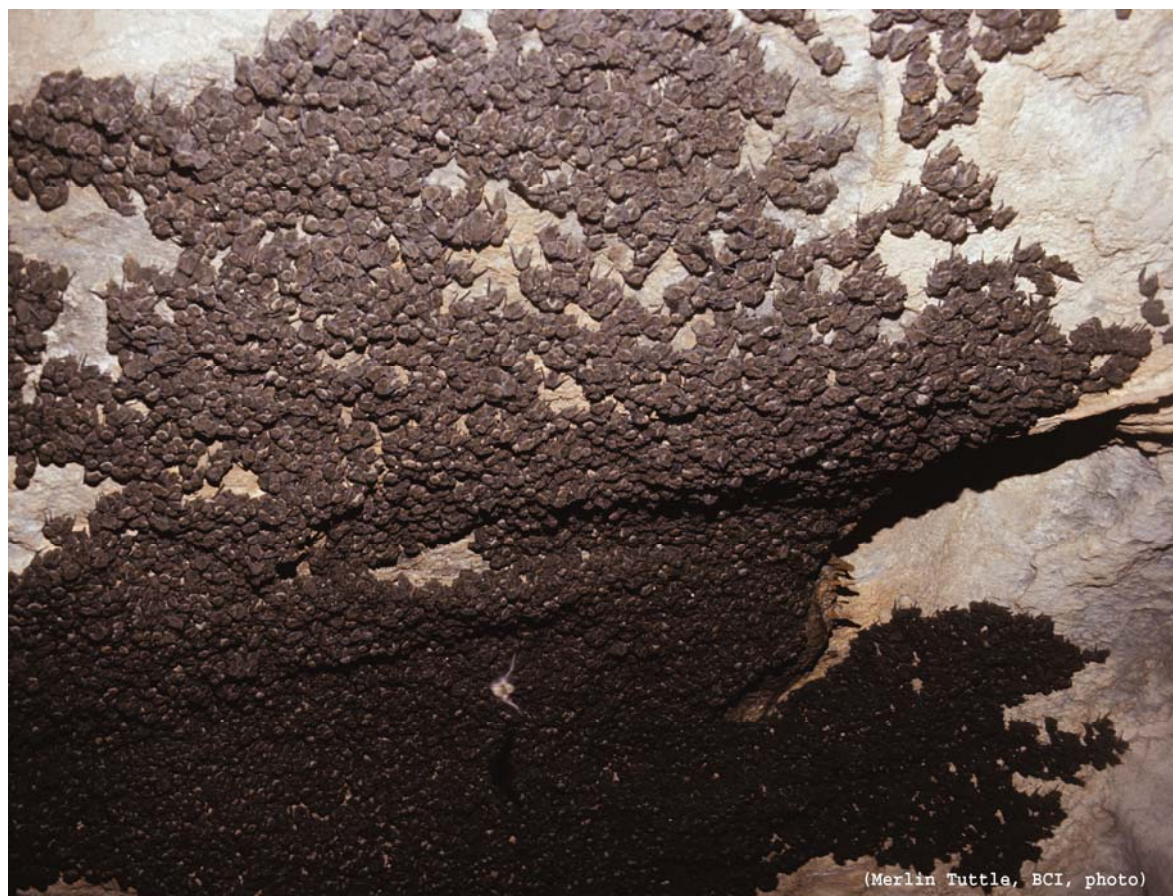
*Army Endangered Species Research Program*

## **Assessment of the Population Status of the Gray Bat (*Myotis grisescens*)**

Status Review, DoD Initiatives, and Results of a Multi-Agency Effort to Survey  
Wintering Populations at Major Hibernacula, 2005-2007

Chester O. Martin

October 2007



(Merlin Tuttle, ECI, photo)

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Final report

Approved for public release; distribution is unlimited.

**Abstract:** The gray bat (*Myotis grisescens*) is a federally listed endangered species known to occur on several U.S. Army installations in the eastern United States. Seven Army installations and one Air Force base have documented gray bat populations, and these facilities have undertaken programs to protect roosting and foraging sites important to the species. This report reviews the status of the gray bat throughout its range and assesses the population status of gray bats at major hibernacula in Arkansas, Missouri, Kentucky, and Tennessee. Survey records obtained from state agencies showed that in recent years gray bat populations have increased significantly in most primary summer and winter caves. In 2005 the Army cooperated with the U.S. Fish and Wildlife Service and other state and Federal agencies to undertake a range-wide survey of primary gray bat hibernacula. Hibernacula surveys were conducted from December 2005 – January 2007 in 11 caves considered to be critical wintering sites. Results of the survey showed stable to increasing population levels across the species' range. Additionally, a Department of Defense Legacy project was implemented to support conservation efforts to assist with recovery of the gray bat. The project funded improvements and protection of several cave sites in Tennessee and Kentucky, hibernacula surveys of selected caves, and summer surveys of maternity caves in Tennessee. The Army Threatened and Endangered Species Research Program also provided support for these tasks. The current range-wide population of the gray bat is estimated at approximately 3.4 million bats.

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## Preface

This study was conducted for the Army Endangered Species Research Program under the Corps of Engineers A896 Direct 6.2 Program; project title “Reassessment of the Population Status of the Gray Bat (*Myotis grisescens*).” The Technical Monitor was Stephen E. Hodapp, Program Manager, Army Endangered Species Research Program, Construction Engineering Research Laboratory (CERL), U.S. Army Engineer Research and Development Center (ERDC), Champaign, IL. Dr. Timothy J. Hayden, CERL, is the current program manager.

The report was prepared by the Ecosystem Evaluation and Engineering Division (EEED), Environmental Laboratory (EL), ERDC, Vicksburg, MS. Chester O. Martin was Principal Investigator for the gray bat work unit. Bill Woodson, previously at Headquarters, Department of the Army (HQDA), provided oversight for the study, interacted with other-agency personnel, and developed a Department of Defense Legacy project that supported efforts to recover the gray bat. Assistance from HQDA was also provided by Scott C. Belfit, Jay M. Rubinoff, and Steven W. Sekscienski, Army Environmental Center. Bruce M. Sabol and Dr. Richard F. Lance, EL, contributed to research design. The following installation personnel provided information on the status of gray bat conservation and management on their facilities: Jim Ratcliff and Bernie Case, Fort McClellan; Danny Dunn, Redstone Arsenal; Kerry Dupaquier, Indiana Army Ammunition Plant (AAP); Gene Zirke, Fort Campbell; Michael G. Brandenburg, Fort Knox; Thomas F. Glueck, Fort Leonard Wood; Bruce G. Cole, Holston AAP; and John W. Lamb, Arnold Air Force Base (AFB). Internal report review was provided by Dr. David L. Price and Dr. Richard A. Fischer, EL. Special thanks go to Kyle R. Richards, Mississippi State University, and Mandy E. Callender, Bowhead Corporation, Vicksburg, MS, for preparing tables and figures used in the report.

Numerous other-agency and private organization personnel contributed work and provided information for this study. Robert R. Currie, U.S. Fish and Wildlife Service (FWS), was instrumental in coordinating work unit activities among state and Federal offices and managing elements of the associated Legacy project. Lewis Gorman was the FWS point of contact for

the Legacy project. Planning guidance for various aspects of the study was provided by Currie and Dr. Paul McKenzie, FWS; Dr. Michael J. Harvey, Professor Emeritus, Tennessee Tech University; Dr. Merlin Tuttle, Director, Bat Conservation International (BCI); Dennis L. Krusac, U.S. Forest Service; Richard Clawson, Missouri Department of Conservation (MDC); and Peggy Horner, MDC. The following nongame and endangered species specialists provided gray bat population data summarized in this report: Clawson; Dr. Harvey; Blake D. Sasse, Arkansas Game and Fish Commission; Keith Hudson, Alabama Department of Conservation and Natural Resources; and Traci A. Hemberger, Kentucky Department of Fish and Wildlife Resources. Tennessee cave data were obtained from Dr. Harvey, Hill Henry (Tennessee Valley Authority), and John W. Lamb (Arnold AFB). Numerous state, Federal, and private cave specialists assisted with hibernacula surveys. Tennessee cave counts were made by Dr. Tuttle, Jim Kennedy (BCI), Kari Gaukler (BCI), and Heather Garland (The Nature Conservancy). Logistical assistance was provided by Mark Thurman, Josh Campbell, and Scott Dykes, Tennessee Wildlife Resources Agency. Dr. Harvey, Currie, Ron Redman, and Sasse surveyed Arkansas caves. Missouri cave surveys were conducted by Clawson and Currie, with assistance from Dr. William R. Elliott, Rita Worden, and Horner (MDC), and Scott House and George Bilbrey, Cave Research Foundation. Summer surveys of Tennessee caves were conducted by Dr. Eric R. Britzke and Ron Redman, Britzke and Associates, Forrest City, AR. External report review was provided by Currie, Sasse, Woodson, Dr. Harvey, Dr. McKenzie, and Dr. Tuttle. Photographs were provided by Dr. Tuttle, Kennedy, and Glueck. The cover photograph by Dr. Tuttle shows gray bats hibernating in Bellamy Cave, TN.

This report was prepared under the general supervision of Dr. David L. Price, Acting Chief, Ecological Analysis and Restoration Branch, EL; Dr. David J. Tazik, Chief, EEED, EL; and Dr. Beth Fleming, Director, EL.

COL Richard B. Jenkins was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.



# 1 Introduction

## Background

The U.S. Army Endangered Species Research Program is responsible for addressing threatened and endangered species (TES) concerns and sponsoring research regarding species that potentially impact the military mission on Army installations. The gray bat (*Myotis grisescens*) (Figure 1) is considered a primary TES species of interest on several Army facilities in the central and eastern United States.



Figure 1. The gray bat (*Myotis grisescens*) is a federally listed endangered species that occurs on several DoD installations in the eastern United States.

The gray bat was listed as federally endangered by the U.S. Fish and Wildlife Service (FWS) in April 1976 (41 FR 17736-17740). Gray bats are year-round cave residents, occupying hibernation caves (hibernacula) in winter and warmer caves in summer (Tuttle 1976a; Gore 1992). Gray bat populations are concentrated in caves in Alabama, Arkansas, Missouri, Tennessee, and Kentucky (U.S. FWS 1982; Harvey 1992a). Summer and winter ranges are similar, but not identical, because different caves are occupied seasonally. The summer range extends eastward from eastern Oklahoma and Kansas to southwestern Virginia and western North

Carolina and southward from southern Illinois and Indiana to northern Florida (U.S. FWS 1982). The major wintering caves are primarily in Tennessee, Missouri, Kentucky, Alabama, and Arkansas.

In the late 1970s, the total population of gray bats was estimated at approximately two million (Tuttle 1979). The population was estimated at 1.6 million in the early 1980s (U.S. FWS 1982) and at 1.5 million within the next 10 years (Harvey 1992a). Recent population data compiled from major hibernacula indicated that the gray bat population using these caves had increased by 16.5 percent over the 1982 estimate. When bat numbers from additional hibernacula were included with these data, the total population showed an increase of 40.4 percent from 1982 and was estimated at approximately 2.3 million bats in 2000 (Harvey 2001). The species' total population was estimated at 2.5 million in 2005; however, approximately 95 percent hibernate in only 17 caves in the following states: Tennessee (5), Missouri (4), Arkansas (5), Kentucky (2), and Alabama (1) (Harvey et al. 2005).

## **Military relevance**

Gray bats are known to occur at seven U.S. Army installations and potentially exist on other Department of Defense (DoD) installations in the south-central United States (Rubinoff et al. 2003). The species has been confirmed on-site at the following installations: Holston Army Ammunition Plant (AAP), TN; Fort McClellan, AL; Indiana AAP, IN; Fort Leonard Wood, MO; Fort Campbell, KY; Fort Knox, KY; Redstone Arsenal, AL, and Arnold AFB, TN (Figure 2). Populations have been reported contiguous to several other installations. Critical habitat for the gray bat has not been designated on any military installation (Rubinoff et al. 2005).

Reassessment of the status of the gray bat directly affects two federally driven initiatives: (1) Improving interagency cooperation by sharing data and other information on issues affecting military training and endangered species management affecting military lands (U.S. Government Accounting Office 2003); and (2) The White House Cooperative Initiative which seeks to foster conservation efforts by bringing together military, Federal, state agencies, and non-government organization (NGO) partners to communicate and achieve common goals (Executive Order 13352, *Code of Federal Regulations*, Title 3, Sections 1-5, August 26, 2004) (Bill Woodson, HQDA, personal communication, 2007). If the gray bat is recovered, some concerns regarding the species on

military installations may be reduced or eliminated. These include certain restrictions on the use of smokes and obscurants, restrictions related to noise and soldier activities, and restrictions related to habitat alteration (Shapiro and Hohmann 2005).

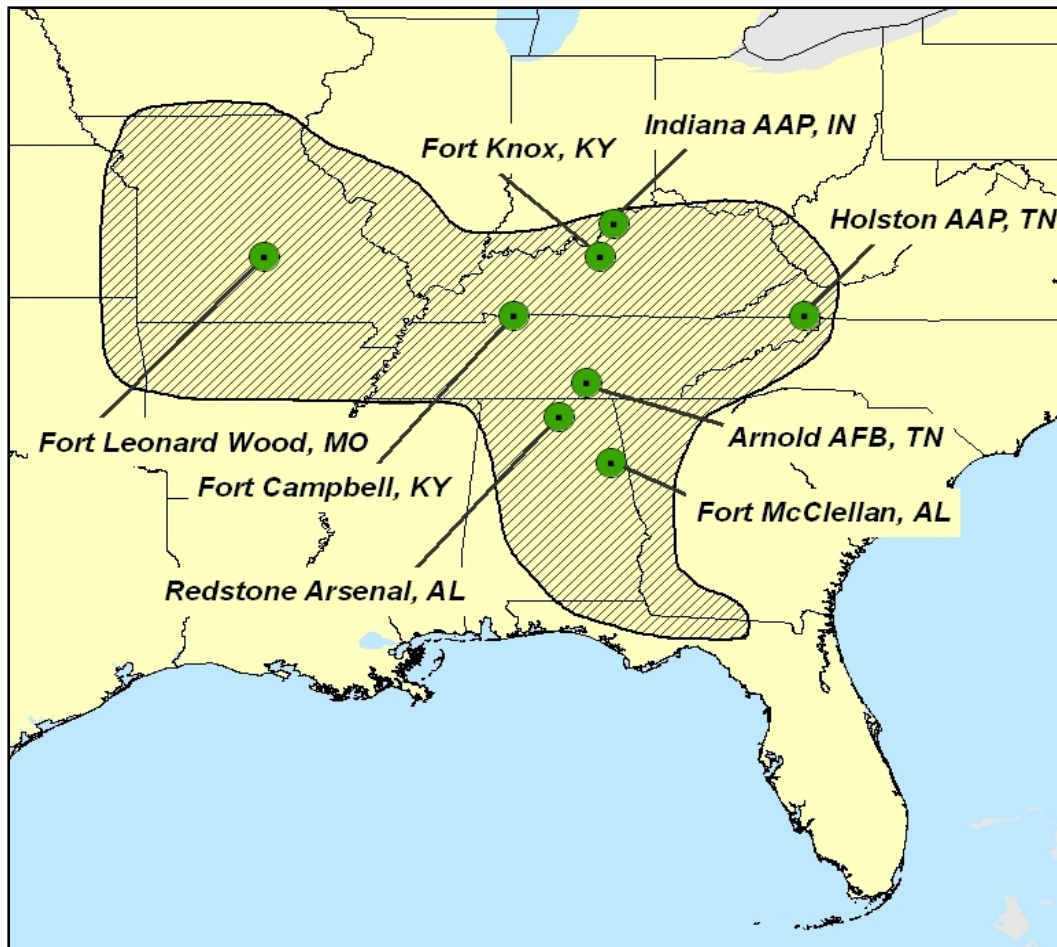


Figure 2. Approximate range of the gray bat, showing location of military installations where gray bat populations have been documented.

## Objective

The major objective of this report is to provide an updated assessment of the status of gray bat populations at major hibernacula in Arkansas, Missouri, Kentucky, and Tennessee.

## Approach

This information is based primarily on coordinated surveys conducted by several agencies and organizations during the winters of 2005-2006 and 2006-2007. The report also provides a review of the status of gray bats in

winter and maternity caves throughout their range, as summarized from the literature and personal communications with gray bat specialists from various agencies and other sources. Finally, recommendations are provided regarding recovery of the species pursuant to the Endangered Species Act.

## **2 Gray Bat Natural History and Population Threats**

An extensive literature exists for the gray bat throughout its range. Many of the early studies dealt with basic ecology, behavior, and characterization of roost sites (e.g., Twente 1955; Hall and Wilson 1966; Tuttle 1975, 1976a, 1976b; Tuttle and Stevenson 1977; LaVal et al. 1977). General information on gray bat ecology, habitat requirements, behavior, population threats, and management are provided below as background information needed to understand the biology, natural history, habitat requirements, and management needs of the species (excerpted from Mitchell 1998 and Mitchell and Martin 2002).

### **Habitat requirements**

#### **Roosting habitat**

Gray bats are year-round cave residents, occupying cold hibernation caves or mines in winter and warmer caves during summer (Tuttle 1976a; Gore 1992). Although numerous caves are available throughout the range of the gray bat, Tuttle (1979) found that only 5 percent of available caves provided suitable gray bat habitat. Both males and females hibernate in the same caves. Gray bats are extremely loyal to specific caves or mines (or to small groups of caves or mines in close proximity) to which they return each winter (Tuttle 2003). Suitable winter hibernacula are typically deep and vertical (U.S. FWS 1982) with multiple entrances, good airflow, and temperatures ranging from 5° to 11°C (42° to 52°F) (Harvey et al. 1999).

On the summer range, hibernation colony members disperse in groups among several different caves with only females occupying maternity caves and others using more peripheral caves (Tuttle 1976a). Colonies select summer caves with temperatures that range from 14° to 25°C (57° to 77°F) (U.S. FWS 1982). Maternity caves are usually the warmest caves in the summer range because they contain structural heat traps, which capture the metabolic heat from clustered individuals (Tuttle 1976a). Only females and their young occupy maternity caves. Gray bats may also occasionally roost at man-made sites that simulate summer caves, such as storm drains (Hays and Bingham 1964; Elder and Gunier 1978; Timmerman and McDaniel 1992). Gunier and Elder (1971) reported an unusual occurrence

of gray bats roosting in a Missouri barn. Lamb (2000) described a maternity colony using a gate-room at Woods Reservoir Dam on Arnold AFB, TN; this site was listed as a priority-two maternity colony in the FWS Gray Bat Recovery Plan (U.S. FWS 1982). Another gate-room of the dam was used by a bachelor colony (Lamb 2000, 2005; Wyckoff 2006a, b).

### **Foraging habitat**

Gray bats forage primarily over water where flying insects are abundant (Tuttle 1976b, 1979; LaVal et al. 1977). Summer colonies inhabit areas where open water (including streams, lakes, and reservoirs) are within foraging distance of caves and other roosting sites suitable for rearing young. In the early evening, gray bats emerge from summer roosts and fly to foraging sites associated with water or wetland vegetation (Clawson 1984; Brack 1985). They usually fly a direct route to feeding areas (Tuttle 1976b) but may fly overland to reach the main river channel or tributary systems that lead to open-water foraging sites (Thomas 1994; Best and Hudson 1996). Summer colonies, especially maternity colonies, prefer caves that are within 1 km (0.6 mile) of a major river or lake and are rarely found in caves located at distances greater than 4 km (2.5 miles) (Tuttle 1976b). Factors closely correlated with distance traveled to feeding areas include growth rate and survival, condition of young bats, and adult mortality. Tuttle (1979) postulated that forested areas surrounding caves or located between caves and foraging habitat are important for gray bat survival. These areas serve as corridors for travel and as protective feeding cover for newly volant (able to fly) young (U.S. FWS 1982). Results of surveys conducted at Arnold AFB indicate that wetland depressions are also important foraging sites for gray bats (Lamb 2000). Thomas and Best (2000) reported that gray bats from one northern Alabama cave foraged over areas of approximately 97 km<sup>2</sup> (37.5 mi<sup>2</sup>).

Gray bats consume a variety of insects that comprise at least 55 families (Clawson 1984; Best et al. 1997). Insect orders important to the diet are flies (Diptera), beetles (Coleoptera), caddisflies (Trichoptera), moths (Lepidoptera), wasps (Hymenoptera), stoneflies (Plecoptera), leafhoppers (Homoptera), and mayflies (Ephemeroptera) (Rabinowitz and Tuttle 1982; Clawson 1984; Brack 1985; Lacki et al. 1995; Best et al. 1997). Studies by Clawson (1984) and Barclay and Bingham (1994) found that dietary components of insectivorous bats are strongly correlated with prey abundance in the area. Both aquatic and terrestrial species are eaten, most of which are less than 10 mm (0.4 in.) in length (Clawson 1984). An

extensive analysis of gray bat fecal pellets and comparison to insect availability in light-trap samples in Missouri revealed that gray bat diets varied among locations, over time, between early-evening and late samples, and among sample groups by sex, age, and reproductive condition (Brack and LaVal 2006). On a micro-scale, gray bats showed some characteristics of an opportunistic forager, but on a macro-scale they were selective, feeding in aquatic-based habitats where specific kinds of insect prey were abundant. Juveniles foraged more frequently in woodlands and ate more beetles than did adults (Brack and LaVal 2006).

## **Behavior**

### **Hibernation**

Gray bats return to the same hibernation sites year after year (Tuttle 1976a). Females usually enter hibernation by early October (U.S. FWS 1982). Males may remain active for several more weeks, but most juveniles and adult males are hibernating by early November. During hibernation the bats become torpid, and the body temperature drops to almost the ambient temperature (Henshaw 1970). This temperature drop allows the body to conserve fat reserves that must last through 6 or 7 months of hibernation and spring migration (Tuttle and Stevenson 1977). Gray bats often hang from cave ceilings in compact clusters composed of several thousand individuals, sometimes several tiers thick, in densities of more than 1800 bats per m<sup>2</sup> (170 per ft<sup>2</sup>) (Hall 1962; Harvey 1975). Indiana bats may hibernate in the same caves with gray bats but usually select slightly different areas of the cave with different temperature ranges (Hall 1962). Hibernation lasts for approximately 6 months (Barbour and Davis 1969).

### **Movements**

Gray bats emerge from hibernation in the spring and move to the summer range, where colony members disperse among several caves (Tuttle 1976a). Adult females migrate to the breeding range in late March or early April, and most adult males and juveniles migrate between mid-April and mid-May. On the summer range, thousands to tens of thousands of reproductive females congregate in a preferred maternity cave to bear and rear young, while adult males and yearlings of both sexes form bachelor groups that occupy other caves (Harvey 1992a). After young become volant, gray bats are more transient within the home range and frequently use alternate roost sites (Thomas 1994). Fall migration occurs in

approximately the same order as spring emergence, with adult females leaving by early September and juveniles departing last, usually by mid-October (Tuttle 1976a). Because of limited suitable hibernacula, gray bats migrate to common hibernation sites across a broad area (Hall and Wilson 1966). Tuttle (1976a) found that one-way distances regularly traveled in migration ranged from 17 to 37 km (10.5 to 23 mi), and bats may migrate as far as 500 km (310 mi) from Florida to hibernacula in Tennessee and northern Alabama. Gray bats demonstrate strong philopatry (loyalty) to both summer and winter ranges. They may use as many as six different caves in the summer range but show no significant movement within the winter range after hibernation has begun (Tuttle 1976a).

### **Reproduction**

Gray bats require 2 years to reach sexual maturity (Tuttle 1976b). Copulation occurs upon arrival at winter caves. Supplemental copulation may occur during the period of hibernation (Guthrie 1933; Miller 1939; Saugey 1978). Females store sperm in the uteri but do not ovulate until they have emerged from hibernation. Fertilization and pregnancy occur soon after females leave the hibernaculum (Guthrie 1933). Gestation lasts for 60 to 70 days (Saugey 1978), and parturition (birth) occurs in late May and early June (Tuttle 1976b). The single, naked young bats cling to adult females for about a week, then remain in the nursery cave while females forage. Most young become volant by 4 weeks of age, usually late June to mid-July (Saugey 1978). For newly volant young, growth rates and survival depend on commuting distances between roosts and foraging areas (Tuttle 1976b). Although juvenile mortality is low (Saugey 1978) and potential longevity is high (up to 17 years), survival to maturity is only about 50 percent (U.S. FWS 1980). Therefore, approximately 5 years are required for a female gray bat to produce two surviving offspring.

### **Threats to gray bat populations**

Although natural factors such as flooding, cave-ins, freezing, and disease occasionally impact gray bats, population decline has been attributed primarily to human disturbance of bats and alteration of their habitat (Barbour and Davis 1969; Mohr 1972; Harvey 1975; Tuttle 1979; U.S. FWS 1982). Hibernacula and maternity caves are especially vulnerable to disturbances. Human entry into a hibernaculum causes bats within range of sound or light to arouse at least partially from hibernation and use energy reserves that cannot be replenished before spring emergence



(Tuttle 1976a). Disturbance at maternity caves is most harmful from late May through mid-July when non-volant young are in the roost, and thousands of bats may die from a single disturbance (U.S. FWS 1982). Human intrusion may also cause the bats to abandon a summer cave (Barbour and Davis 1969). Human activities that have resulted in major impacts to bat colonies include cave exploration (Harvey 1975), cave commercialization (U.S. FWS 1982), and vandalism (Tuttle 1979). Incidents of intentional vandalism have included shooting bats (Tuttle 1979), cave bombing with gasoline bombs (Harvey 1975), and extermination by property owners because of unsubstantiated fear of bats and rabies (Fredrickson and Thomas 1965).

The most outstanding impacts caused by human environmental alterations probably result from deforestation and chemical contamination. Deforestation near cave entrances and between caves and rivers or reservoirs may cause adverse effects to bat populations, including decrease in prey availability, decrease in foraging efficiency, and increase in vulnerability to predators (Tuttle 1979). Newly volant young receive greater protection in forest cover, as they are slow, awkward fliers and often spend several nights foraging in the forested area surrounding the nursery cave during the first week of flight.

The effects of agricultural pesticides on the decline of gray bat populations were reviewed by Mitchell (1998) and Shapiro and Hohmann (2005). Clark et al. (1978) documented mortality in gray bats and probable population decline resulting from insecticide use. Organochlorine pesticide residues have been documented to kill gray bats even though these compounds have been banned for most uses since the 1970s and early 1980s (O'Shea and Clark 2002). In 1983, dead gray bats were found in Missouri with concentrations of heptachlor epoxide pf 2.6 µg/g to 6 µg/g. Two gray bats found dead in 1991 were presumed killed by heptachlor epoxide, chlordane, and dichlorodiphenyldichloroethylene (DDE; Clawson 1991). Lethal quantities of dieldrin were found in bats in Indiana and Missouri prior to the mid-1980s. Bats collected in 1996 and 1997 showed a high incidence of dieldrin exposure, but a low probability of lethal levels (O'Shea and Clark 2002). The current concern is the threat of modern pesticides, such as organophosphates and carbonates; these compounds are highly toxic cholinesterase inhibitors but are not fat soluble, thus they may kill bats from direct exposure but are not expected to bioaccumulate in tissues (Shapiro and Hohmann 2005).

Sasse (2005) analyzed contaminants detected in gray bat guano collected from four caves in Arkansas. Samples were analyzed for the presence of 25 chemical compounds. Thirteen of 15 samples contained p,p'-DDE (a breakdown product of dichlorodiphenyltrichloroethane or DDT) with values ranging from 0.011 to 0.057 ppm (dry weight). This compound was found in samples from every cave examined, whereas dieldrin was detected in only 2 of 15 samples. Heptachlor epoxide was not found in any of the samples. The study confirmed that, although the pesticide concentrations detected were low compared to levels reported in previous studies (e.g., Clark et al. 1988; Clawson 1989), gray bats in Arkansas caves have been and are continuing to be exposed to pesticide residues that are potentially fatal. Sasse (2005) recommended periodic monitoring of pesticide concentrations in guano and carcasses of dead bats because of the continued influence of banned pesticides and increasing use of new compounds in agricultural regions.

Shapiro and Hohmann (2005) discussed military activities potentially harmful to gray bats. These included pesticides (discussed above), smokes and obscurants, habitat modifications, and noise. Research conducted on Fort Leonard Wood focused on inhalation toxicity for two chemicals, hexachloroethane (HC) and terephthalic acid (TPA), that are the major components of many common military obscurant devices (3D/Environmental 1996). HC is the more toxic compound and has been eliminated on some installations (e.g., Fort Leonard Wood) to protect endangered bats (Shapiro and Hohmann 2005). 3D/Environmental (1996) reported that bats roosting or foraging within 10,000 m (10,937 yd) of one HC smoke pot may be affected by inhalation of unsafe concentrations of toxic components of the smoke; the risk of inhalation toxicity from TPA smoke pots was initially documented as significant within 2,000 m (2,187 yd) of use. However, reanalysis showed significance at 90 m (98.4 yd) (Thomas Glueck, Fort Leonard Wood, personal communication, 2007). Polycyclic aromatic hydrocarbons (PAHs) are components of fog oil smoke and are of concern because they are considered significant carcinogens (Schmidt et al. 2002). However, tissue analyses of bats collected at Fort Leonard Wood and reference sites on the Mark Twain National Forest showed no evidence that fog oil used on the installation increased risk from these chemicals (Schmidt et al. 2002; Shapiro and Hohmann 2005).

Although noise can potentially affect the behavior of some species, recent studies have not shown measurable effects of military noise on bats. 3D/Environmental (1996) examined the potential for various firing activities (e.g., demolitions, artillery, grenade simulators) and heavy equipment operation to disturb hibernating Indiana bats and a maternity roost of gray bats on Fort Leonard Wood. Their research found that sound from munitions and equipment generally attenuated prior to reaching roost sites. Additionally, research was recently conducted to determine the effects of military noise, primarily high-caliber weapons fire, on foraging bat activity on Fort Knox (Martin et al. 2004; Martin 2005). The study obtained measurements of bat vocalizations using ultrasonic bat detectors, thermal infrared (TIR) imagery, and military noise monitoring technology. Statistical analysis of bat vocalizations, TIR detection, and military noise data showed extremely large variations in bat response across space and time, and results indicated that elevated noise levels associated with high-caliber weapons fire, as tested, did not have a significant effect on bat navigation and foraging activity (Martin et al. 2004). Additional work is underway at Army research laboratories to assess the potential of high-caliber weapons fire to cause temporary or permanent hearing loss, interference of echolocation, and disruption of diurnal thermoregulatory behavior (Shapiro and Hohmann 2005).

Immediate mortality and long-term loss of roosting habitat are potential concerns in respect to military activities and land development actions (Shapiro and Hohmann 2005). Primary concerns for the gray bat include modifications to cave sites and foraging habitat, especially waterways and riparian areas. However, all installations with known populations of gray bats have developed, or are developing, endangered species components to their Installation Natural Resource Management Plans (INRMPs), which have incorporated habitat protection and management guidelines for gray bats. Available information suggests that habitat conditions for gray bats have improved substantially since the early 1990s (see installation summaries in Chapter 3).

### **3 Gray Bats on Military Installations**

As previously noted, Rubinoff et al. (2003, 2005) reported that gray bats occur on seven Army installations and are known from sites contiguous with other installations. Table 1 lists military facilities where gray bat populations have been documented or potentially occur. In May 2006 the Army Environmental Center (AEC) requested information from each Army installation that has a known population of gray bats. This data call requested information on recovery criteria (prevention of disturbance to important roost habitat; maintenance, protection, and restoration of foraging habitat; and monitoring of population trends), biology and habitat (habitat or ecosystem conditions; spatial distribution and trends in spatial distribution; and abundance and population trends), and threats, conservation measures, and regulatory mechanisms for protection of gray bat populations. These responses are summarized below and supplemented with selected literature sources. General information is also provided from a U.S. Air Force installation and Army Corps of Engineers projects where gray bats are known to occur. Figure 2 shows the range-wide distribution of gray bats and approximate location of military installations where gray bats have been documented.

#### **Fort McClellan Army National Guard Training Center, AL**

Fort McClellan is composed of approximately 9025 ha (22,300 acres) in northeastern Alabama. Foraging habitat for bats includes 14.5 km (9 mi) of streams with two 1.6-km (1-mi) tributaries and about 202 ha (500 acres) of open wetlands. Fort McClellan has no roosting habitat, but three to four roosting caves occur within foraging distance of the installation; one of the caves is Weaver Cave. The availability of foraging sites has been stable and constant over the past 5 years; the stream corridor serves as primary foraging habitat. The installation has a current Endangered Species Management Component (ESMC) of its INRMP that provides for management of the gray bat. The plan has been approved by the U.S. FWS and the State of Alabama. Management consists of protecting wetland and riparian areas and restricting pesticide applications. The stream and corridor have been designated a Special Interest Natural Area. No activities are permitted within 50 m (164 ft) of the creek, and no pesticide applications are allowed within 300 m (984 ft). Gray bat population trends are not monitored, but presence/absence surveys are conducted

approximately biennially by mist-netting, acoustic detection using Anabat II detectors, or radio telemetry. Three monitoring surveys have been conducted in the past 5 years (Jim Ratcliffe and Bernie Case, Fort McClellan, personal communication with AEC, 2006).

**Table 1. Known and potential occurrence of gray bats on military installations within the species' geographic range (after Shapiro and Hohmann 2005).**

Installation/Base	Roost Occurrence	
	Maternity	Hibernacula*
Redstone Arsenal, AL	Documented	Adjacent co.
Anniston Army Depot, AL	Adjacent co.	
Fort McClellan, AL	Documented	
Fort Rucker, AL	Adjacent co.	
Fort Chaffee, AR?	Same co.	
Pine Bluff Arsenal, AR?	Adjacent co.	
Indiana AAP, IN	Documented	
Kansas AAP, KS	Adjacent co.	
Blue Grass Army Depot, KY	Same co.	
Fort Campbell, KY	Documented	Same co.
Fort Knox, KY	Documented	Same co.
Camp Crowder, MO	Adjacent co.	
Fort Leonard Wood, MO	Documented	Adjacent co.
Camp Clark, MO	Adjacent co.	
Camp Gruber, OK	Adjacent co.	
Tullahoma TS, TN	Adjacent co.	Adjacent co.
Volunteer AAP, TN	Adjacent co.	Adjacent co.
Holston AAP, TN	Documented	Same co.
Arnold Air Force Base, TN	Documented	
* Only primary hibernacula (25,000 to 50,000 individuals) were considered. ? State bat biologists from Arkansas are not aware of any gray bat caves in Franklin or Sebastian counties where Fort Chaffee is located, and no colonies are known from locations nearby.		

## Redstone Arsenal, AL

Redstone Arsenal consists of approximately 16,188 ha (40,000 acres) bordering the Tennessee River. About 4,092 ha (10,000 acres) are wetlands, and approximately 25 percent of the installation can be considered foraging habitat. No gray bat roosts are on Redstone Arsenal, but known roosting caves occur within 8.0 km to 16.1 km (5 to 10 mi) on two sides of the installation. Population trends are not monitored, but

mist-net surveys are conducted on a periodic basis. Mist-netting was conducted in 1995 and 2005, with gray bats documented as present during both periods. A bat study was initiated in 2006 that includes additional mist-netting. The installation INRMP (U.S. Army Redstone Arsenal 2005) has a current (2006) ESMC that provides for management of the gray bat. The plan has been approved by the FWS and the state. Management consists of protection of wetland and riparian areas and restriction of pesticide applications (Danny Dunn, Redstone Arsenal, personal communication with AEC, 2006).

### **Indiana Army Ammunition Plant (AAP), IN**

Indiana AAP is located on 3,962 ha (9,790 acres) in extreme southeastern Indiana. The installation has been declared excess to the Army and is being disposed of; all military missions have ceased. Approximately half of the installation is or will be under control of the Indiana Department of Natural Resources (IDNR) by ownership or lease agreement. The IDNR will use the land for outdoor recreation, but the Army has assured that deed and lease restrictions are in place requiring that the state protect gray bat habitat. Indiana AAP has no known gray bat roost sites, but foraging habitat is present and includes small streams and riparian areas. Primary foraging areas are Jenny Lind Creek and Little Battle Creek. The portion of the installation that is under state control contains all of the available foraging habitat. The property being acquired by the state will also be fenced to control access. Indiana AAP has an INRMP dated 1997 and an ESMC dated April 2000 that provides for management of the gray bat (Indiana AAP 1997, 2000). Current management practices consist of access restrictions to foraging areas; protection of stream, riparian, and karst areas; and restriction of pesticide applications in foraging areas. Tree planting recently accomplished along a stretch of Jenny Lind Creek was part of an industrial site clean-up project (Kerry Dupaquier, Indiana AAP, personal communication with AEC, 2006).

Gray bat management at Indiana AAP is a collective effort among the Army, IDNR, and FWS. Gray bat population trends have not been monitored on Indiana AAP, but presence/absence and habitat use data are obtained by periodic mist-netting and radio-telemetry studies. Mist-netting and telemetry surveys were conducted in 1997, 1998, and 2004. Results of bat surveys on Indiana AAP were published in a recent FWS report (King 2005). This study established that most of the gray bats foraging on the installation roost at Sellersburg Quarry in Sellersburg, IN.

A follow-up study is planned for 2008 and will likely be the responsibility of the IDNR (Kerry Dupaquier, personal communication with AEC, 2006).

### **Fort Campbell, KY**

Fort Campbell is a large Army installation in southwestern Kentucky consisting of approximately 42,494 ha (105,000 acres). The installation contains two lakes 32.8 ha (81 acres) and 7.3 ha (18 acres) in size, and 679 km (422 mi) of streams in nine sub-watersheds. Fort Campbell has no known gray bat roosting sites, but a geophysical survey in 2005 discovered nine caves, and the installation is in the process of assessing the status and roosting value of these caves. Ninety percent of Fort Campbell is potential foraging habitat for bats. Bats are surveyed biennially using mist-netting, Anabat II detectors, and radio-telemetry. A total of 291 gray bat mist-net captures (including recaptures) have occurred since 1998, which constitutes 40 percent of all bats captured during survey periods. Trends show a slight increase of gray bats captured (one to two percent) since 1998 (based on surveys of foraging bats) (Gene Zirkle, Fort Campbell, personal communication with AEC, 2006).

Fort Campbell's INRMP has a current ESMC that provides for management of the gray bat (U.S. Army Fort Campbell 2007). The plan has been approved by the FWS and the state. Conservation actions consist of protection and restoration of foraging habitat. Based on integrated land use priorities, the installation is developing Total Maximum Daily Load criteria for streams to improve water/foraging quality. Priority watersheds are evaluated by impairments, and improvements are developed and implemented to improve water quality and increase the in-stream insect yield. Intermittent and permanent streams are protected by 15.2 m (50 ft) and 30.5 m (100 ft) buffers, respectively. Pesticide use in stream corridors is restricted. Basically, no activities occur in stream corridors without coordination with the installation TES biologists. The installation participates in the Tennessee Bat Working Group, which facilitates sharing of information and integration of regional management (Gene Zirkle, personal communication with AEC, 2006).

### **Fort Knox, KY**

Fort Knox, located in north-central Kentucky, consists of approximately 44,112 ha (109,000 acres). It contains 88.5 km (55 mi) of streams, 22 ponds and lakes, and 955 ha (2,359 acres) of wetlands. Two known bat

caves occur on Fort Knox. Grahamton Cave and McCracken Cave are in the Otter Creek watershed adjacent to Carlson Lake along the western boundary of the installation. Gray bats have been reported to roost in both caves during the spring, summer, and fall months, with the greatest numbers present in March and September (Carter and Merritt 1995). Gray bats have not been observed in these caves during winter surveys (White et al. 1994). Survey data suggest that the Fort Knox caves are used as transitional roosts during migration between summer and winter habitats, and during foraging trips from primary summer caves (BHE Environmental, Inc. 2001). Although there is evidence that a gray bat colony with as many as 10,000 bats may have occupied Grahamton Cave in the past (Bryan and MacGregor 1982; White et al. 1994), recent surveys have estimated fewer than 150 individuals (137 in Grahamton Cave in September 2000; 91 and 50+ reported respectively from McCracken Springs Cave in 1994 and 2000). Eight additional caves have been located on Fort Knox, but gray bats have not been documented for any other caves surveyed (BHE Environmental, Inc. 2001).

Carter and Merritt (1995) suggested that gray bats roosting in Grahamton and McCracken Caves likely forage along major Fort Knox watercourses (Otter Creek, Rolling Fork, Salt River, Mill Creek) and their tributaries. During mist-net surveys conducted in 1992 and 1993 by White et al. (1994), seven male gray bats were captured in mist-nets along Otter Creek. During 2002-2003 mist-net surveys, four male gray bats were captured at sites along Cedar Creek in the extreme southern part of the installation and at Upper and Lower Otter Creek in the west-central region (C. O. Martin, unpublished data). Gray bats were recorded at numerous sites in watersheds throughout the installation using Anabat II detectors during 2002-2004 surveys (R. F. Lance, unpublished data). They were particularly active over Upper and Lower Douglas Lake in the southern part of the installation. Although gray bat numbers appear to have dwindled in Fort Knox caves, they were recorded frequently during recent summer Anabat II surveys. It is apparent that gray bats use a variety of riparian and aquatic resources available on Fort Knox (Martin et al. 2006).

Fort Knox was the setting for a study conducted during 2002-2004 to investigate the potential impacts of military training noise, primarily high-caliber weapons fire, on the behavior of bats. Standard mist-netting procedures and ultrasonic sound detection using Anabat II detectors were used to determine the presence of bats in selected areas. Anabat II and



TIR cameras were used simultaneously to monitor bats subjected to high-caliber weapons fire, rocket fire, machine gun fire, and helicopter noise (Martin et al. 2004). Statistical analysis of bat vocalizations, TIR imagery, and military noise data showed extremely large variations in bat response variables across space and time. No consistent significant differences were found in measures of bat activity associated with military noise at a fixed site (i.e., firing and non-firing times at the same site), firing and non-firing sites, or types of military noise. Thus, results indicated that elevated noise levels associated with high-caliber weapons fire, as tested, did not have a significant effect on bat navigation and foraging activity at the established Fort Knox firing ranges (Martin 2005). Although limited data were collected specifically on gray bats as part of this study, no evidence suggested that this species responded differently than other bats monitored.

Conditions for gray bats have improved on Fort Knox over the past 10 years as a result of stream protection, improved gates on two caves, emphasis on natural resources reclamation, and established buffers around streams and sinkholes. The entrance to Grahampton Cave is protected by a suitable fence, and the entrance to McCracken Cave is protected by remoteness and a sign. The installation has a current INRMP that provides for management of the gray bat (U.S. Army Fort Knox 2003). The plan is approved by the FWS and the state. A current Integrated Pest Management Plan is coordinated with the INRMP, and special care is taken to reduce pesticides used in or near water resources. The installation protects a 21.3 m (70 ft) buffer around all water resources, including sinkholes. Two low-water crossings for military vehicles have been constructed on Otter Creek to protect water quality and prevent the need for military vehicles to enter the creek. Best management practices are used in soil-disturbing activities, and Soil Erosion Control Plans are used when required by the Clean Water Act. Under the Base Realignment and Closure (BRAC) Act (U.S. DoD 1990), the mission at Fort Knox will change. The new mission is expected to have less impact on natural resources than the current mission (Mike Brandenburg, Fort Knox, personal communication with AEC, 2006).

## **Fort Leonard Wood, MO**

Fort Leonard Wood, located in south-central Missouri, comprises 24,853 ha (61,410 acres), including 10 streams with 54.7 km (34 mi) of permanent flow. The Big Piney and Roubidoux streams, 16.1 km (10 mi)

and 20.9 km (13 mi) long, respectively, are classified as Type 1-major streams. Eight other streams, 17.7 km (11 mi) in length, are categorized as Type 2 – smaller streams. The total acreage of riparian habitat on the installation is estimated at 1,214 ha (3,000 acres), all of which is considered gray bat foraging habitat. Fort Leonard Wood is near the center of gray bat range in Missouri, and is also near the center of counties occupied by the “central subpopulation” in the state (3D/Environmental 1996). Most bats in the central subpopulation hibernate in Coffin Cave in Laclede Co. This subpopulation is the largest in Missouri in respect to the number of bats, number of maternity caves, and geographic area occupied. Gray bats within the central subpopulation are characterized as stable to increasing (Missouri Department of Conservation (MDC) 1992; Richard Clawson, MDC, personal communication, 2006).

Several caves located on Fort Leonard Wood and in the vicinity of the installation are known to provide roosting habitat for gray bats. A gray bat maternity colony occurs in Saltpeter No. 3 Cave (Figure 3). The state conducted an exit count of Saltpeter No. 3 Cave in 2002/2003 and estimated a population of 3,000 to 5,000 gray bats. Freeman Cave is used as a roost site by transient gray bats during migration (3D/Environmental 1996). Evidence suggests that Freeman Cave may have been used as a maternity roost in the past. There are also four Indiana bat caves where small numbers (15-20) of gray bats have occasionally been found wintering with Indiana bats (Thomas Glueck, personal communication 2006). Great Spirit Cave, located 3.5 km (2.2 mi) west of Fort Leonard Wood, also supports a maternity colony (MDC 1992, 1994; Thomas Glueck, personal communication, 2006). A number of caves within a mile of the installation contain bachelor groups, and these bats are believed to forage on the installation.



Figure 3. Salt peter No. 3 Cave (above) and Freeman Cave (below) provide roosting habitat for gray bats on Fort Leonard Wood, MO (photographs courtesy Thomas Glueck).

Habitat on the installation has become more favorable for gray bats during the past 12 years due in part to improved protection of caves, protective measures around riparian zones, and reduction in pesticide usage. An endangered species awareness program has also been implemented on the installation. Gray bat management guidelines specific to Fort Leonard Wood are included in the installation ESMC. Although the ESMC has not been officially endorsed by the FWS, the Service has concurred with the management and conservation strategies for the gray bat. Revisions to both the ESMC and the INRMP (U.S. Army Fort Leonard Wood 2000) have been completed and are under review by the state and FWS. Management and protection related to gray bats at Fort Leonard Wood is accomplished, in part, through protection zones and use restrictions related to operational activities. Signs restricting human access during the roosting season (1 April to 31 October) are posted at the entrance to Saltpeter No. 3 Cave and Freeman Cave. Infrared monitors are set up in a number of caves to detect disturbance. These devices are checked twice seasonally and disturbances are recorded. Entrances of caves are also tracked to detect unauthorized activity. Unauthorized entry has been greatly reduced by monitoring the caves and enforcement of security measures to reduce unauthorized entry onto the installation. Additional habitat management and restrictions regarding gray bats are as follows (T. Glueck, personal communication with AEC, 2006):

- Maintain a contiguous forest canopy through uneven age timber management or protection in the immediate 8.1 ha (20 acres) above and around the opening of the cave.
- Maintain restrictions on activities within an additional 57 ha (140 acres) surrounding the cave to ensure integrity of travel corridors for access to riparian foraging areas.
- Maintain general controls within 1 km (0.62 mi) of caves for additional protection (e.g., the Natural Resources Team must be contacted prior to any tree removal within this zone).

The Natural Resource Team also monitors use of riparian areas. In order to maintain water quality of streams, the installation has implemented the following measures:

- No filling or digging around riparian areas without a permit.
- Control of bivouacking on a case-by-case basis.

- Control of stream crossings only at fording sites (small streams have low-water crossings).
- No off-road use of vehicles.
- No pesticide usage within riparian areas.

Additional gray bat conservation measures implemented by the installation include restricting the use of fog oil smoke for training during the active nightly bat foraging period, planting 5.7 ha (14 acres) within the area of Roubidoux Creek to improve foraging habitat, implementing water quality management efforts through monitoring sedimentation and storm water control, and eliminating timber harvesting within riparian zones. The installation has an agreement with MDC for monitoring (T. Glueck, personal communication with AEC, 2006).

Several gray bat field studies were conducted during 1994 and 1995 to provide data on gray bat populations and potential impacts of military operations on Fort Leonard Wood. Mist-net surveys were conducted to determine the distribution of gray bats on the installation during the summer of 1994. Noise and seismic studies were performed in an attempt to determine the response of gray bats in Saltpeter No. 3 Cave to military-generated airborne and substrate-borne sound. Insect sampling provided a baseline description of available gray bat prey species, and fecal sampling characterized local gray bat prey. These studies are described in detail in 3D/Environmental (1996).

### **Holston Army Ammunition Plant, TN**

Holston AAP consists of 2,438 ha (6,025 acres). Potential foraging habitat available to gray bats includes 7.2 km (4.5 miles) of the Holston River and 1.61 km (1.0 mile) of the Arnott Branch, for a total of 36.4 ha (90 acres). Two caves are on the installation. These caves were surveyed in 2002 and found not to be serving as roost habitat. No maternity roosts are known within 16.1 km (10 mi) of the installation. Gray bat population trends are not monitored, but some mist-netting has been done in the past and more is planned for the future (Bruce Cole, Holston AAP, personal communication with AEC, 2006).

Holston AAP has an INRMP (Holston AAP 2000) that was approved by the FWS and State of Tennessee in 2000. The INRMP is being updated, and an ESMC addressing the gray bat is 85 percent complete. Ongoing management includes protection of riparian areas, planting trees along the

river and stream, and use of state best management practices in stream/river corridors. Both caves are protected from human activity although they are not currently used for roosting. The installation recently completed 457 m (1,500 ft) of new stream by diverting production facility cooling water. This diversion created new foraging habitat and maintained the original stream insect production capability. BRAC plans include establishing a new Army Reserve/National Guard training capability at Holston AAP. This action will not result in a threat to gray bats (B. Cole, personal communication with AEC, 2006).

### **Arnold Air Force Base, TN**

A summer gray bat colony has been documented at the Woods Reservoir Dam on Arnold AFB, a 15,822-ha (39,096-acre) installation located in south-central Tennessee. This colony was listed as a priority-two maternity colony in the Gray Bat Recovery Plan (U.S. FWS 1982) and is one of a few of maternity colonies determined to use manmade structures for maternity roosts (Lamb 2000). In 2000 a gray bat colony monitoring project was established to (1) monitor the reproductive status of the maternity colony, and (2) monitor overall colony success by estimating the area of guano coverage on surfaces in the gate rooms of the dam. Expansion joints in ceilings of the gate rooms are primary roosting locations. The area inhabited by the bats is posted and restricted, but an unknown individual disturbed the colony in 2000 by climbing into the dam and turning on lights near the bats. The bats did not return that year, but this access point has since been gated. Although no structural changes have been made to the dam, the estimated number of gray bats in the colony has declined significantly since monitoring began in 1998. Radio-telemetry data collected in 2003 indicate that many gray bats from this colony have moved to more suitable roost sites along the escarpment of the Cumberland Plateau (Lamb 2005; Wyckoff 2006a, 2006b). The maternity colony at Woods Reservoir Dam was absent in 2005, but a bachelor colony was present (Lamb 2005). However, a small cluster of 85 juveniles was observed in one of the gate rooms in June 2006 (Wyckoff 2006a, 2006b).

Subsequent studies conducted by Arnold AFB personnel included Anabat II surveys for gray bats, identification of foraging habitats, determining the spatial extent of foraging habitats, and annual monitoring of the Woods Reservoir colony (Lamb 2000, 2005). At the request of the FWS, attempts were made to capture and radio-track bats foraging on Arnold AFB to



determine their colony of origin, but this effort was largely unsuccessful because gray bats are known to forage up to 28 km (17 mi) from their roosts (Laval et al. 1977). Foraging distances of 15 to 35 km (9.3 to 21.8 mi) were noted by Thomas and Best (2000) in Alabama. In order to determine the link between bats foraging on Arnold AFB and colonies off base, a long-term project was initiated in 2004 to capture and band gray bats on base and at other known colonies in the area. A total of 698 gray bats has been banded on base and at three caves near the installation (Wyckoff 2006a).

### **Army Corps of Engineers**

Records maintained by Headquarters, U.S. Army Corps of Engineers (USACE), show that gray bats and their habitats are managed as part of recovery plan efforts on 15 projects in Kentucky, Tennessee, Missouri, Arkansas, and Kansas. Caves used by summer colonies of gray bats have been managed to control flooding at Beaver Lake, AR; Harry S. Truman Lake, MO; and Nolin River Lake, KY. An artificial entrance was built at Beaver Lake to replace the natural entrance, which was below the flood control pool, and pumps were used at Harry S. Truman Lake to transfer storm and spring drainage away from a cave containing a maternity roost. The Corps built an artificial entrance to Pigeon Roost Cave, Benton Co., AR. The entrance is a metal culvert that has a solid metal door that can be shut, but is left open. The entrance is fenced but not gated. A gray bat cave, Lands End Cave, is also located adjacent to Corps property associated with Lake Dardenelle (Arkansas River) in Pope Co., AR (Blake D. Sasse, Arkansas Game and Fish Commission, personal communication, 2006). At Harry S. Truman Lake, Beck and Blackwell Caves (both located in Hickory Co., MO) are sites of historic gray bat maternity roosts and have been managed by the Corps and the MDC since the late 1970s. Both caves are located in remote locations and have been protected by signs and fencing. The entrance to Blackwell Cave is protected from human intrusion by a framework constructed of steel bars (Mike Watkins, USACE Kansas City District, personal communication, 2006). At Nolin River Lake, a large nursery colony is located in a cave that opens onto a cliff on the edge of the summer pool; the opening to the cave is on Corps property, but the domed areas used as roosts are on private property. When floodwaters have to be stored, the Louisville District coordinates closely with the FWS to implement appropriate protective measures (Mitchell and Martin 2002). The Nashville District recently provided support to the FWS and Tennessee Nature Conservancy to gate the Dud's and Haile cave systems near Cordell

Hull Lake in Jackson Co., TN. District personnel also formulated a management plan for the cave systems to ensure the long-term management of the resources, formalized the partnership agreement, and helped coordinate logistics (Foshee 2002).



## **4 Review of Population Status**

### **Gray bat trends and survey methods**

A series of papers regarding monitoring trends in bat populations was recently published as a U.S. Geological Survey Information and Technology Report (O'Shea and Bogan 2003). The report resulted from a workshop that included participation from leading experts in sampling and analysis of wildlife populations and bat biology and conservation. Information from the report relevant to the status of gray bat populations is summarized in the following paragraphs.

Tuttle (2003) stated that population monitoring was relatively straightforward for gray bats because they typically concentrate in relatively conspicuous groups of tens of thousands of individuals that live year-round in caves along waterways. Although estimating their exact numbers remains difficult, they aggregate in predictable fashion at specific summer nursery roosts, where they stain ceilings and leave large guano deposits that allow relatively consistent population estimates. Counts may be difficult, however, because bats form clusters of varied density, often high above the cave floor, which forces observers to estimate numbers based on knowledge of normal clustering behaviors and densities for each species. Tuttle (2003) emphasized that the most reliable means of determining roosting density is to construct a sturdy frame that encloses a specific area within which all bats can be counted (Tuttle 1975; Thomas and LaVal 1988). He further stated that, while conducting winter surveys, all assumptions made regarding clustering densities and areas covered by bats should be recorded for each roosting area. Additionally, where assumptions or estimates are made without actual measurements, they should be made and recorded independently by at least two individuals (Tuttle 2003).

Kunz (2003) noted the following methods historically used for censusing bats: roost counts, evening emergence counts, evening dispersal counts, and disturbance counts. A combination of traditional census methods and recently developed remote censusing techniques was suggested to offer the greatest promise for estimating population sizes of most species. TIR imaging was discussed as a promising technique for censusing bats as they emerge from roosts. An advantage stated for TIR imaging was that individuals can be censused independent of the ambient light at the time

of emergence. Successful application of the method, however, requires a uniform background behind the bats so that this background can be digitally subtracted from the images of emerging bats (Kunz 2003). The TIR imaging process for bat surveys is described in Sabol and Hudson (1995) and Melton et al. (2005). Kunz (2003) stated that censusing hibernating bats is best achieved by counting each individual bat or group of bats as they are encountered, or by estimating the mean density of bats in several representative clusters, and extrapolating this density to the total area of the cave wall or ceiling that is covered by bats. Kunz (2003) suggested that surveys of hibernating bats should be limited to one census period every other year. Various census methods are further described in the following section under state surveys.

Ellison et al. (2003) compiled 1,879 observations of gray bats gathered from 334 roost locations throughout the species range. The majority of observations were collected from Missouri (735), Arkansas (377), Alabama (273), and Kentucky (194). Counts included maternity colonies (866), transient roosts (301), hibernacula (196), and bachelor colonies (101). Thirty percent of the observations were made after 1990. Information was analyzed from counts at 103 summer colonies and 12 hibernacula in Alabama, Arkansas, Florida, Illinois, Kansas, Kentucky, Missouri, and Tennessee. The majority of the data from summer colonies showed no trend; nine indicated an upward trend and six a downward trend. Also, no trends were detected for 7 of the 12 hibernating colonies; 3 showed an upward trend and 2 a downward trend. Few data were said to be available for gray bat hibernation sites because of their sensitivity to disturbance. Even though this compilation of data from various sites did not show an obvious trend in gray bat populations, Ellison et al. (2003) stated that recovery efforts by the FWS and others have suggested that gray bat numbers have rebounded in recent years. At the time the Recovery Plan was written, the gray bat population was thought to be approximately 1,657,900 across its range. In 2002 the total population was estimated to be 2,678,137—an increase of 62 percent from the time the plan was written (Ellison et al. 2003). The 2006 population was estimated at 3,377,100—an estimated increase of 104 percent from 1982 (Harvey and Currie 2007).

Sasse et al. (2007) reported the results of population surveys from 48 gray bat maternity sites over a 25-year period (1978-2002) in the western portion of the species' range in Missouri, Arkansas, and Oklahoma. Population estimates were made using different techniques (e.g.,

measurement of guano deposits, exit counts, estimates of cave ceiling area covered by colonies) in each state, but were generally constant at each cave so that estimates at each site among years could be compared. Three subpopulations were identified in the region. Overall, gray bat populations at 21 of 48 (44 percent) maternity caves showed a significantly increasing trend, whereas 17 (35 percent) showed no discernable trend, and 10 (21 percent) were decreasing. In the northern subpopulation (central Missouri), 13 of 15 (87 percent) of maternity colonies had either stable or increasing populations, 8 of 10 (80 percent) were increasing or stable in the eastern subpopulation (southeastern Missouri), and 18 of 23 (78 percent) were stable or increasing in the southern subpopulation (southwestern Missouri, northwestern Arkansas, northeastern Oklahoma, and extreme southeastern Kansas). Results of these surveys show a much higher percentage of caves with increasing maternal populations than those reported by Ellison et al. (2003), which relied on a much smaller sample size than that examined in the Sasse et al. (2007) study. Sasse et al. (2007) concluded in their study that the dramatic decline in gray bat populations that led to the species' listing as endangered in 1976 may have halted and that maternal populations appear to be recovering in the western portion of its range.

## **State surveys**

State agencies were contacted to obtain recent and historical data on gray bat populations within caves in their respective states. Detailed information was provided by the states of Alabama, Arkansas, Kentucky, Missouri, and Tennessee. This information is summarized in the following text and associated tables. An attempt was made to provide comparisons of population counts from the most recent surveys and selected surveys in past years. Data are not necessarily comparable among states because of differences in content and format in the information provided. Appendix A provides a more thorough listing of gray bat caves by state throughout the species' range.

### **Alabama**

Gray bats are known from approximately 40 cave systems in 11 counties in northern Alabama. Since their listing, concerted efforts have been made to assess the status of gray bats through an annual inventory of selected caves throughout their range in Alabama. A comprehensive historical review of bats in troglodytic caves in Alabama was conducted as part of a 1993

endangered bat cave survey. Information presented below and in Table 2 is summarized from recent annual reports prepared for the Nongame Wildlife Program of the Alabama Department of Conservation and Natural Resources (Hudson 2002, 2003, 2004, 2005).

**Table 2. Summary of gray bat summer survey data from Alabama caves, 2002-2005 (after Hudson 2002-2005).**

Cave		County	2002	2003	2004	2005
<b>Priority-1 Caves (7)</b>						
Sauta Cave	(1st Count)	Jackson	235,000	230,000	170,000	452,900
	(2nd Count)			235,000	173,750	310,000
	(3rd Count)				113,500	210,000
Cave Springs Cave	(1st Count)	Morgan	12,404	17,050	13,860	11,100
	(2nd Count)		35,500		47,400	
Fern Cave	(Hibernaculum)	Jackson	-	1,270,000 +	*	*
Georgetown Cave		Colbert	0	-	-	0
Hambrick Cave	(1st Count)	Marshall	28,658	23,107	27,281	36,482
	(2nd Count)		35,650	-	-	
Key Cave		Lauderdale	33,402	31,514	34,916	48,800
Sanders Cave		Conecuh	*	*	*	-
<b>Priority-2 Caves (13)</b>						
Anderson Cave		Shelby	6,670	4,450	5,550	200
Baker Cave		Colbert	4,450	4,350	5,770	5,650
Blowing Spring Cave	(1st Count)	Lauderdale	17,500	7,850	4,650	6,800
	(2nd Count)				4,250	
Dunham Cave		Marshall	*	0	*	*
Gross Skeleton Cave		Jackson	0	*	*	*
Guntersville Caverns		Marshall	**	**	**	**
Indian Cave		Limestone	3,700	3,720	4,120	3,650
King's School Cave		Marshall	*	*	*	150
Lykes Cave		DeKalb	*	*	*	*
Nitro Cave		Jackson	*	*	*	*
Old Blowing Cave		Marshall	*	*	6,225	*
Shelta Cave		Madison	~6****	-	-	~6
<b>Priority-3 Caves (15)</b>						
Bishop Cave		Marshall	~50	*	*	*
Collier Cave		Lauderdale	-	24	5	-
Hering Cave		Madison	*	*	*	*
Hollyberry Cave	(AL Bat Cave #1)	Lauderdale	12,300	1,200	1,150	1,250
Honeycomb Cave		Marshall	0	*	*	*
Horse Skull Cave		Jackson	*	*	*	*

Cave		County	2002	2003	2004	2005
Hughes Cave		Morgan	*	*	26****	*
King's Spring Cave		Marshall	*	*	*	*
Ledbetter Cave		Marshall	*	45****	*	*
Little Nat Cave		Jackson	***	***	***	***
McKinney Cave	(Pit) #2	Colbert	*	70	50?	*
Orcestrwells Cave		Jackson	*	*	*	*
Stanley - Carden Cave		DeKalb	800	*	*	*
Talucah Cave		Morgan	*	*	*	*
Woody Cave		Morgan		*	*	*
<b>Other Caves</b>						
Cathedral Caverns		Marshall	-	-	-	-
Davis Bat Cave	(1st Count)	Lauderdale	475	1,840	500	6
	(2nd Count)		300	<12****		12
Sublett Springs Cave		Madison	4,200	*	3,980	5,500
Armstrong Cave		Lawrence	18****	-	*	*
Cave Mountain Cave		Marshall	5****	*	*	*
Jess Elliot Cave		Jackson	-	*	*	*
Russell Cave National Monument (Main Ent.)		Jackson	6?	-	*	*
Rock House Cave		Covington	0	*	*	*
Honeycomb Mine	(1st Count)	Marshall	*	300	3,400	50
	(2nd Count)					550
	(3rd Count)					4,200
Hope Cave		DeKalb	*	*	*	*
Backward/Confusion Cave		Lawrence	*	-	*	*
Mountain Springs Cave		Lawrence	*	-	*	*
Section Cave		Jackson	*	0	*	*
Collier-Bone Cave		Lauderdale	*	0	*	*
Flutter Putter Cave		Jackson	*	*	150	*
* Cave was not surveyed that year ** Access was denied *** Cave entrance collapsed **** Mixed species						

Priority caves listed for Alabama in the Gray Bat Recovery Plan include 7 Priority-1 caves, 13 Priority-2 caves, and 15 Priority-3 caves. Sauta Cave in Jackson Co. supports an unusually large maternity colony, with more than 230,000 bats estimated in 2002 and 2003 surveys, and 452,900 counted in June 2005 (Hudson 2005). Significant numbers have also been

recorded in Cave Springs Cave, Hambrick Cave, and Key Cave. Fern Cave is a major gray bat hibernaculum.

Alabama caves known to regularly contain more than 100 bats during the summer are surveyed between mid-May and early October of each year. Night vision scopes, infrared lighting, and ultrasonic bat detectors are used to aid in observing bats at most sites. Summer emergence estimates are made by counting (or estimating) the number of bats seen exiting cave openings during 1-minute intervals. Bats are counted for 1 minute, then not counted for the following minute as the observer rests and records; the process is repeated continuously until the emergence is complete. An estimate of total emergence is obtained by doubling the number counted. Recent surveys have shown that gray bat numbers have generally remained stable in most of the major caves surveyed (Hudson 2004, 2005).

Several cave sites have received additional protection through improvements in fencing and cave gates. For example, recent improvements include a chain-link fence erected around Baker Cave, re-fencing Indian Cave, and re-gating both upper and lower entrances of Sauta Cave (Hudson 2002, 2003, 2004). In August 2004, the FWS re-gated both upper and lower entrances to Sauta Cave, which contains the largest summer colony of gray bats in Alabama. Sauta was subsequently monitored during the summer of 2005 to determine effects of the new gating. The June estimate of 452,900 was the largest emergence recorded at the site in 14 years. It appeared that the new gating did not have a negative effect on the colony and likely enhanced the site (Hudson 2005).

A major undertaking in 2003 was a winter survey of Fern Cave, which is the largest gray bat hibernaculum in Alabama and contains the greatest concentration of gray bats within the range of the species. Hibernating bats are extremely difficult to count in the cave due to the distance between areas that contain bats and the extensive vertical descent required to reach roosting sites (Hudson 2002, 2003). Experienced cavers with Bat Conservation International (BCI) and the National Speleological Society attempted to conduct a full survey on 20 January 2003, but some sites could not be accessed and not all areas of the cave expected to contain hibernating bats were visited (Hudson 2003). Estimates of gray bat numbers from the surveyors ranged from 413,600 to 1,271,000, averaging 842,300. The large variation in estimates made it difficult to determine

the precise status of gray bats at Fern Cave; nevertheless, the cave apparently serves as an extremely important hibernaculum.

Periodic surveys of gray bat caves on Tennessee Valley Authority (TVA) lands throughout the Tennessee River Valley are included as part of the TVA Regional Natural Heritage Project's monitoring program (Henry 2004). Surveys in 2002-2003 included three caves in Alabama: Collier, Key, and Hambrick Caves. Collier Cave was apparently used only during spring and fall migration. A sign was installed in the entrance, and temperature units were placed throughout the cave. Key Cave is considered one of the most biologically significant caves in the Southeast (Henry 2004). The cave apparently supports a maternity colony, as 22,510 adults and 4,324 young bats were counted in the cave on 4 June 2003. Henry et al. (2005) conducted an emergence and roost count at Key Cave on 7 June 2005 and estimated 31,932 adults and 8,460 young, for a total of 40,392 gray bats. Hudson (2005) reported an estimate of 48,800 gray bats for the same period. Henry et al. (2005) estimated 23,107 gray bats during early June surveys at Hambrick Cave in 2003 and 26,059 in 2005. Hudson estimated 36,482 bats at Hambrick Cave at a later date in 2005. Numbers of adult gray bats have increased 28 percent at Key Cave and 34 percent at Hambrick Cave since last surveyed (Henry et al. 2005).

### **Arkansas**

An estimated 350,000+ gray bats hibernate in 5 Arkansas caves, and approximately 180,000+ gray bats are known to occur in approximately 20 Arkansas caves during the summer (Harvey et al. 2005). Others migrate from Arkansas hibernacula to summer caves in southern Missouri, eastern Oklahoma, and southeastern Kansas. Several additional caves serve as transient caves for gray bats. Important Arkansas hibernacula include Bonanza Cave, Blanchard Springs Caverns, and Cave Mountain Cave (Table 3).

Hibernating gray bat numbers in Arkansas caves were estimated by counting individual bats or estimating the area in square feet covered by clusters of bats and multiplying by 170 (Harvey et al. 2005). Estimates of summer colonies were made by direct observation of bat clusters, measurement of fresh guano deposits, or by estimating the number of bats leaving the cave at dusk. Because of inter-cave movements by gray bats during the summer, it was difficult to obtain a reliable estimate of the Arkansas summer population. Since only one or two maternity caves were

monitored each night, movement of bats between caves could have resulted in overestimating or underestimating populations by counting individuals more than once, or by missing some bats altogether. In addition, estimates of numbers of bats exiting large maternity or bachelor colonies are difficult and are probably imprecise. The 2004-05 total gray bat count at 8 maternity sites was 128,660, which represents an increase of approximately 39,530 over the previous summer's estimate (Harvey et al. 2005).

**Table 3. Six year summary of population data for gray bats in Arkansas (Harvey et al. 2005).**

Cave Name	County	Colony Type	Max Before 1999	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Bald Scrappy Cave	Stone	T	12,000	0	0	0	0	0	0
Bennett Cave	Carroll	T	2,500	—	50 C	18 C	24 C	3,060 F	—
Bergren Cave	Izard	T	7,700	0	170 C	85 C	0	—	0
Big Creek Cave	Searcy	M	18,000	5,100 C	3,060 C	3,068 C	8,000 C	3,060 C	1,700 F
Blagg Cave	Sharp	M	13,000	—	—	0	0	—	—
		T	—	—	1,360 C	—	—	—	—
Blanchard Springs Caverns	Stone	B	42,000	6,500 C	20,600 C	17,000 C	—	5,780 C	2,870 C
		H	71,000	85,000 C	81,900 C	147,850 C	95,600 C	97,000 C	116,620 C
Bonanza Cave	Baxter	H	250,000	—	150,000 C	55,000 C	89,500 C	107,710 C	—
Bone Cave	Independence	M	156,000	102,000 C	86,700 C	136,000 C	85,000 C	25,500 C	38,250 C
Brewer Cave	Boone	T	2,200	—	0	—	—	—	—
Cave Mountain Cave	Newton	H	70,000	200,000 C	172,500 C	234,850 C	145,530 C	320,450 C	127,500 C
Cave River Cave	Stone	M	27,000	—	340 C	50 C	2,000 C	4,080 C	—
Cave Springs Cave	Benton	M	22,000	2,300 C	1,200 C	2,030 C	—	1,800 C	5,630 C
Corkscrew Cave	Newton	H	7	—	—	—	—	—	—
Crane Cave	Searcy	B	7,700	0	0	0	—	0	11,220 C
Crystal Cave	Benton	B	28,600	1,360 C	3,400 C	19,040 C	12,750 C	17,850 C	11,220 C



Cave Name	County	Colony Type	Max Before 1999	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Dodd Cave	Independence	T	24,000	2,040 C	2,550 C	425 C	2,040 F	680 C	1,360 C
Edgman Cave	Newton	H	7	—	—	—	27 C	66 C	12 C
Elm Cave	Marion	T	5,000	—	—	—	—	680 C	340 C
Fallout Cave	Searcy	B	17,000	2,720 C	27,200 C	3,400 C	—	5950 C	0
Fitton Cave	Newton	H	80 C	1	0	42 C	0	28 C	33 C
Flea Cave	Newton	T	500	1,530 F	9 C	6 C	—	—	—
Gustafson Cave	Stone	H	—	—	0	0	0	2 C	0
Hankins Cave	Independence	H	1,030	0	0	0	—	—	0
Hell Creek Cave	Stone	A	16,500	—	—	0	—	—	—
Hidden Spring Cave	Stone	H	70	0	0	0	0	0	0
Horseshoe Cave	Newton	B	40,460	25,500 C	17,000 C	17,000 C	15,300 C	31,110 C	13,430 C
		H	600	3,000 C	0	0	85 C	12 C	0
Horsethief Cave	Madison	M	30,000	12,240 C	8,840 C	6,800 C	11,200 C	13,770 C	32,130 C
Huffman Cave	Marion	B	20,000	—	4,250 c	1,700 C	—	0	3,500 C
		H	9,500	—	—	6,000 C	2,200 C	3,000 C	3,400 C
Joe Bright Cave	Stone	T	8,900	—	0	—	—	—	—
		H	—	—	—	14 C	40 C	—	0
John Eddings Cave	Newton	B	10,000	1,360 F	30 C	—	2,720 C	1,250 C	—
		H	50	23 C	5 C	120 C	—	0	10 C
Jones Cave	Lawrence	T	4,000	—	2,550 C	—	—	5,440 C	—
Lands End Cave	Pope	T	1	—	850 c	0	680 C	3,000 C	0
Logan Cave	Benton	M	25,000	9,400 C	11,200 C	18,970 C	16,700 C	20,650	29,000 C
Morris Cave	Sharp	T	5,000	—	1,530 F	1,020 C	850 C	0	1,530 C
Newark Storm Sewer	Independence	M	8,000	840 C	10,000 C	3,172 C	10,719 C	8 C	4,420 C
Norfork Cave	Baxter	T	2,720	0	340 F	0	0	0	10,200 C
Old Joe Cave	Baxter	M	54,700	5440 C	6,120 C	6,120 C	5,442 C	8,540 C	17,800 C

Cave Name	County	Colony Type	Max Before 1999	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Optimus Cave	Stone	T	7,000	170 F	340 F	0	140 F	88 C	680 C
		H	—	—	—	—	—	1 C	—
Ozark Acres Cave	Sharp	T	11,000	—	8,500 F	170 F	0	—	3,400 F
Peter Cave	Searcy	B	21,000	—	0	0	280 F	5 C	510 C
Pigeon Roost Cave	Benton	T	15,000	510 C	—	170 C	—	0	10 C
Rory Cave	Stone	T	9,000	—	—	—	—	0	—
Rowland Cave	Stone	H	70	0	0	0	0	2 C	0
Shirley Bat Cave	Van Buren	B	10,200	—	340 F	—	—	3,000 C	—
Silver Valley Mine	Boone	T	1,500	—	0	0	—	—	—
Still Cave	Baxter	H	30,000	—	3,000 C	1,350 C	750 C	1,870 C	—
Summer Cave	Marion	M	14,800	13,600 C	11,730 C	4,080 C	8,160 C	11,730 C	—
War Eagle Caverns	Benton	B	20,000	—	1,410 C	19,550 C	—	3,400 F	—
Wet Cave	Boone	B	37,800	—	340 F	—	140 C	0	—
Wolf Creek Cave	Newton	H	49	1	0	0	0	37 C	0
		T	23	—	—	0	—	—	—
Colony Type H = hibernation; M = maternity; T = transient; A = abandoned. Method of Estimate: C = count; F= fresh guano.									

Harvey et al. (2005) reported that it was difficult to make an accurate estimate of the total gray bat population in Arkansas for several reasons. Bonanza Cave was particularly troublesome because of the cave configuration. Prior to 1999 the usual estimate had been around 250,000, but during the winter of 1998-99 a large portion of the bluff above the cave entrance collapsed, destroying the gate and partially blocking the entrance. The cave was re-gated with an improved gate configuration during the summer of 2002. The hibernating population was estimated at 55,000 in 2002 but rebounded to an estimate of 107,710 in 2003-04. The cave was not checked in 2004-05 (Harvey et al. 2005). The 2006 population was estimated at 148,750 (see Chapter 5).

Blanchard Springs Caverns contained a gray bat hibernating colony of 5,000 to 7,000 prior to development as a tourist attraction by the U.S. Forest Service. Construction in the caverns began in 1963, the cave was open to the public in 1973, and the population decreased to a low of 33 bats in 1985-86. The Forest Service then limited disturbance to the roost site, and the population increased dramatically to a population of 116,620 in 2004-05 and increased to 128,005 in 2006. The summer bachelor colony increased to an all-time high of 42,000 in the summer of 1993, and during the summer of 2005 an estimated 2,870 bats were observed exiting the cave (Harvey et al. 2005).

Hibernating colonies of both gray bats and Indiana bats inhabit Cave Mountain Cave on Buffalo National River lands. Prior to the winter of 1990-91, the greatest number of hibernating gray bats reported for the cave was 700, and only 50 gray bats were counted in 1981-82. The cave was fenced by the National Park Service during the summer of 1982, and closed to visitation during the hibernation period. Since this time, the winter population gradually increased to an all-time high of 320,450 during 2003-04. Approximately 127,500 gray bats were estimated during the winter of 2004-05 (Harvey et al. 2005). The 2006 winter population was estimated at 139,740 (see Chapter 5).

## **Kentucky**

Gray bat population data from Kentucky caves were provided by Traci Hemberger (Kentucky Department of Fish and Wildlife Resources (KDFWR), personal communication, 2006). Summer emergence counts from 1989 through 2005 were provided for 21 caves (Table 4). Figure 4 shows summer emergence counts for selected caves surveyed in 2004 compared with counts in previous years. Although there have been considerable fluctuations in counts among years, the general trend indicates a stable to increasing population for most sites. Caves with the largest estimated populations (10,000+) since 2003 include Caney Branch, Jones, Mutters, Overstreet, Phil Goodrum, Riders Mill, and Watt caves. Hemberger (personal communication, 2007) stated that the data provided for Kentucky represented only the caves that are now surveyed on a 2-year cycle and that many other sites have historically had small numbers of gray bats.

Two Priority-1 gray bat hibernacula, Jesse James Cave and Coach Cave, are located in Kentucky. The historic name for Coach Cave is Hundred

Dome Cave (T. Hemberger, personal communication, 2006). Both Coach and Jesse James Caves are privately owned by the same absentee land owner, who resides in Mexico. The state has been trying to secure the caves for years with no success. Both caves are gated. Combined winter counts for these sites have increased from 100,000-150,000 in 1969/70 to 269,500 in 2005. The actual number of bats in Jesse James Cave could not be determined in 2005 because access was cut off to primary bat hibernacula sites in the cave. Hibernacula data show a substantial upward trend in the wintering bat populations in these caves from the 1960s to present. A high count of 300,000 was estimated in 1997. Both caves have had large population fluctuations over the past 5 years, but the overall winter populations show an increasing trend (T. Hemberger, personal communication, 2006). The Coach Cave population was estimated at 264,000 in 2005, and the Jesse James count was 95,500 in 2003 (Michael J. Harvey, Tennessee Tech Univ., personal communication, 2006). A survey of these caves in January 2007 resulted in an estimate of 412,900 hibernating gray bats (Robert Currie, FWS, personal communication, 2007) (see Chapter 5).

## **Missouri**

There are 52 known gray bat maternity sites in Missouri (R. Clawson, MDC, unpublished data). The total population of maternal colonies was estimated at 794,010 in 2004, compared with 721,000 in 2000; 670,050 in 1995; and 456,100 in 1980. The historical population estimate for all maternity caves was 1,498,650 (pre-1975). A variety of methods have been used to estimate maternity populations, including stain, guano, and exit counts. Table 5 shows summary data for Missouri caves in selected years. A recent study by Sasse et al. (2007) found that 87 percent of maternity colonies had either stable or increasing populations in the Central Missouri population, and 80 percent were stable or increasing in southeastern Missouri.

**Table 4. Gray bat summer emergence counts from selected Kentucky caves (1989-2005).**  
**Modified from data provided by Traci Hemberger, Kentucky Department of Fish and Wildlife Resources.**

Cave Name	County	1989	1994	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Big Sulphur	Trigg	2,046			292		1,450		567		572		827	
Boones	Taylor	24,937*		20,597		8,940		22,635		38,733		19,283		15,107
Bryant Edmunds	Barren	1,730	3,376*		114		91		794		770		181	
Burgess	Nelson	863*	333*		4,546		526		4,075		2,887		2,711	
Buzzard Roost	Monroe				11,514	6,125		10,515*		41		8,697		11,746
Caney Branch	Clinton	13,831		22,625		236		13,439		12,239		11,341		11,598
Carpenter	Allen	770*	1,858*		4,118		10,511		12,969		7,315		11,799	
Cool Springs	Trigg	1,280			1,031		3,663		4,112		2,922		1,774	
Glass Farm	Franklin	331			199		1	411	516/ 1,012	659	622		737	
Jones	Adair	14,189*		16,741		16,344		17,463		12,436		30,935	25,044*	18,768
Mutters	Barren	7,452	10,895*								15,245*		37,000	
Overstreet	Jessamine	7,944		5,775		20,124		13,571		21,790		14,876		14,803
Payne	Barren		3,570*		13,210		6,615		9,521		6,226		16,313	
Phil Goodrum	Allen	15,679*	5,315*	20,147		14,269		18,912		9,100		18,863		28,734
Riders Mill	Hart	20,434*		12,095		18,851		18,878		31,574		29,393		
Robertson	Monroe							2		13,998		9,511*		
Smoky	Simpson	15,298*		20,010		14,260		15,987		12,284		11,831		11,704
Son of Finney	Warren	1,120			7,274		1,411		76		1,053		16	
Sulphur Creek	Metcalfe	469*	2,330*		20		227		20		1,052		13	
Watt	Warren						16,550			12,138		19,756*		8,016***
Wax Jr.	Grayson			8,656		7,095		0	0	0		unknown**		

\* Estimate may include volant young based on timing of survey.

\*\* Some bats had reoccupied the cave but were killed in a flood prior to surveying.

\*\*\* Incomplete survey; beginning of emergence missed.

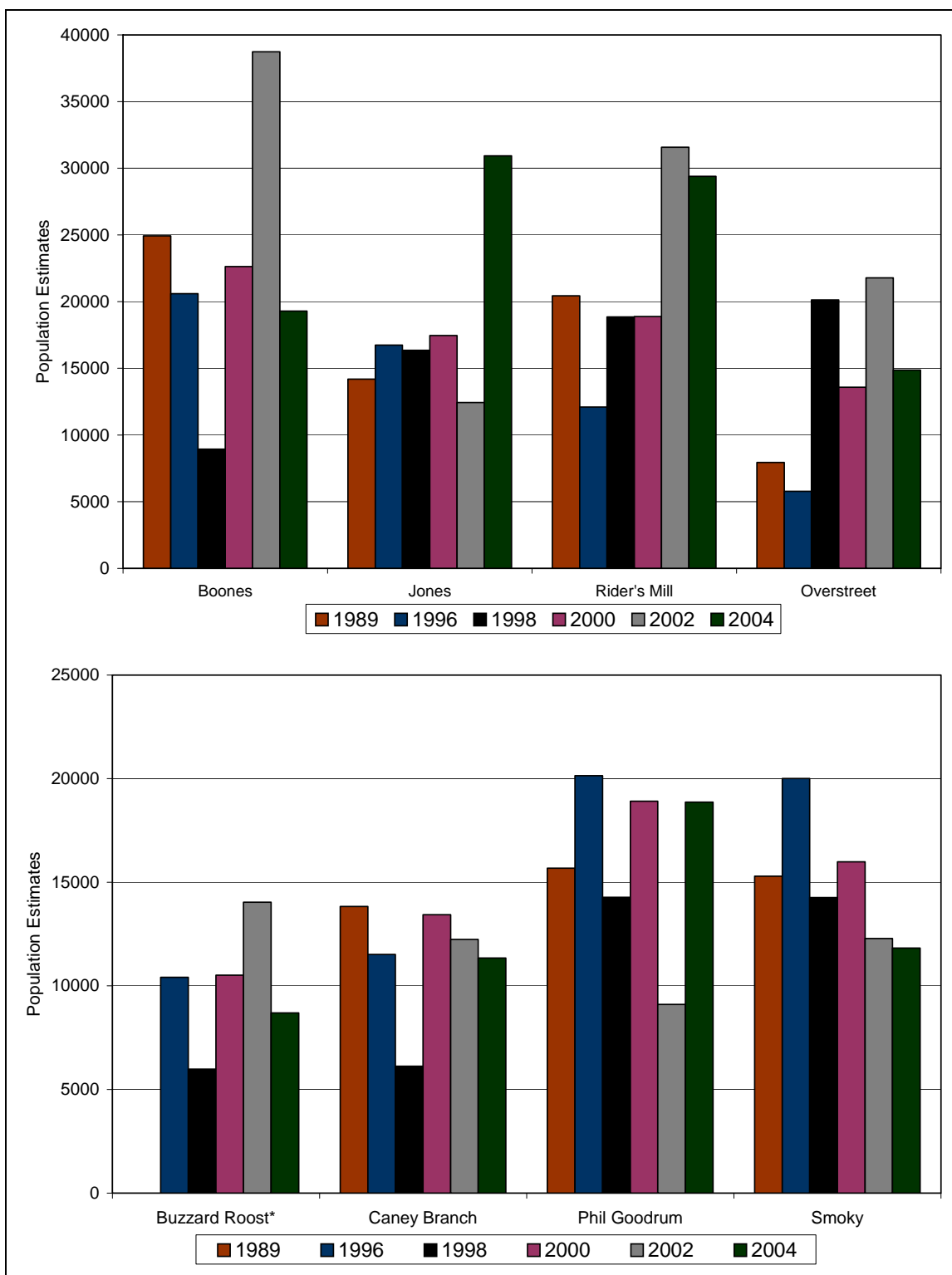


Figure 4. Summer emergence counts for selected gray bat caves in Kentucky (1984-2005) (Traci Hemberger, Kentucky Department of Fish and Wildlife Resources, 2006).

Priority-1 hibernacula in Missouri are Coffin Cave, Mose Prater Cave, and Bat Cave (Shannon Co.).<sup>1</sup> Coffin Cave is in Laclede Co. in the mid-central region of Missouri, and Mose Prater and Bat Caves are in the southeastern part of the state. Historically, Marvel Cave in southwestern Missouri served as a wintering site, but the cave has been commercialized and can no longer be considered a hibernaculum. Coffin Cave is owned by the MDC and is currently protected with a fence. The cave supported a historical population of 150,000 gray bats, and in 1979 the population was estimated at 250,000. Since then the population has fluctuated from approximately 300,000 to 350,000; a survey conducted in 1984-85 resulted in an estimate of 355,450 bats (R. Clawson, personal communication, 2006). The 2006 winter population in Coffin Cave was 561,000 (see Chapter 5).

Mose Prater and Bat Caves are in Shannon Co. Mose Prater Cave is owned by the National Park Service, and Bat Cave is owned by The Nature Conservancy (TNC). Both caves are protected by fences. The historical population for Mose Prater Cave was 135,000. The population decreased to 53,900 in 1976, reached 112,200 in 1982-83, and was estimated at 93,000 in 2002-03. The 2006 count was 155,000. Bat Cave had a historical population of 25,000, dropped to a low of 9,100 in 1975-76, and slowly increased to 57,850 in 2004-05; the 2006 population was 27,600 (R. Clawson, personal communication 2006). Table 6 provides summary data for current and historical estimates of gray bat populations in Coffin, Mose Prater, and Bat Caves (MDC data).

Mary Lawson Cave in Laclede Co. historically supported as many as 97,000 gray bats, estimated from the maximum extent of guano in the cave (Elliott and Hedgpeth 2006). The colony was as small as 18,300 in 1978 and has fluctuated greatly since that time. The cave was acquired by the MDC in 2003 for protection of this Priority-2 Indiana bat and gray bat site. It was gated in April 2004 with a modern half gate (flyover gate). An improved count method using infrared videography resulted in an estimate of 71,615 bats in July 2005, but the guano method only estimated 35,400 bats in September 2005. Although there is apparent inconsistency in estimates based on different counting methods, the Mary Lawson Cave gray bat population has likely increased since the cave gate was constructed. Work is ongoing to restore surface vegetation to more natural conditions and improve the surrounding forest habitat for bats (Elliott and

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<sup>1</sup> The county designation distinguishes the cave from several other caves known as "Bat Cave" in the state.

Hedgpeth 2006). A proposal to purchase Mary Lawson Cave via a Recovery Land Acquisition Section 6 grant has been submitted and a final decision is pending.

**Table 5. Summary of gray bat maternity populations in Missouri for selected years (modified from data provided by R. Clawson, MDC).**

Cave Name	County	Historical Population	1977-1978	1985-1986	1994-1995	2000-2001	2003-2004
Adkin's	Camden	10,800	10,950	30,000	36,725	-	29,400
Bat	Dent	29,250	-	29,250	23,800	36,700	29,400
Bat	Miller	20,000	-	-	Present	-	26,100
Bat	Oregon	10,800	7,300	4,000	1,825	9,800	-
Bat	Ozark	33,250	12,800	21,000	27,200	-	60,950
Bat	Texas	9,000	-	2,000	-	-	34,000
Bat No. 1	Franklin	91,800	-	0	-	-	0
Bat No. 1	Hickory	3,600	0	-	-	-	-
Bat No. 2	Franklin	3,600	1,800/ 3,000	0	Present	46,250	-
Bat No. 3	Franklin	1,200	-	3,650	8,225	17,150	-
Beck	Hickory	31,000	31,000	Present	Present	Present	Present
Blacksmith	Barry	26,500	-	Present	13,600	-	8,150
Blackwell	Hickory	27,000	5,500	9,500	12,250	9,000	11,400
Bob and Mark No. 2	Ozark	9,150	-	Present	-	-	-
Brown No. 1	Pulaski	50,000	-	44,000	41,050	39,200	39,800
Carroll	Camden	38,000	-	-	-	-	-
Coalbank	Carter	8,100	7,300	4,000	11,900	8,200	-
Competition Bat	Laclede	Unknown	0	6,000	-	-	-
Cooks	Reynolds	70,000	10,950	19,500	Present	11,500	15,500
Coolbrook	Jasper	5,400	7,300	1,500	5,350	-	-
Dead Man	Oregon	Unknown	-	-	1,825	8,150	-
Devil's Icebox	Boone	2,000	-	-	9,200	13,050	12,150
Estes	Benton	3,000	2,200	2,500	1,375	-	-
Fisher	Franklin	87,700	-	-	0	-	-
Fisher	Ralls	16,500	12,800	-	-	-	-
Frankford	Pike	3,000	0	-	0	-	-
Grandpa Chipley's	Camden	50,000	Present	-	-	Present	17,700



Cave Name	County	Historical Population	1977-1978	1985-1986	1994-1995	2000-2001	2003-2004
Great Spirit***	Pulaski	250,000	36,600	11,600	12,250	0	0
Holton	Boone	2,000	3,700	1,000	3,425	3,750	-
Lower Burnt Mill	Camden	10,800	0	16,450	Present	-	-
Mary Lawson	Laclede	97,000	18,300	19,000	36,550	28,550/ 34,300	54,400
Maze	Dade	9,000	5,500	-	8,150	-	7,350
McDowell	Miller	11,000	-	-	-	7,800/ 9,860	-
Moles*	Camden	40,000	36,600	-	Present	43,500	54,400**
No Name	McDonald	14,000	-	1,000	4,750	-	13,050
Onondaga	Crawford	Unknown	-	-	-	-	-
Piquet	Pulaski	36,000	0	7,300	Present	-	22,000
Rantz	Christian	18,000	12,800	33,000	14,275	-	10,600
River	Camden	23,000	Present	0	21,425	9,800	52,200
Roaring Spring	Franklin	14,000	Present	19,500	-	0	-
Rocheport	Boone	5,000	0	-	0	35,650	39,500
Round Spring	Shannon	60,300	-	-	0	-	-
Saloon	Crawford	Unknown	5,400	15,000	-	-	-
Saltpeter	Stone	33,000	Present	-	Present	-	21,750
Smittle	Wright	50,000	-	105,500	51,175	-	36,700
Round Spring	Shannon	60,300	-	-	0	-	-
Stillhouse	Stone	3,500	-	3,800	5,475	-	5,500
Thrasher Ford	Oregon	Unknown	-	8,100	3,400	6,550	-
Toby*	Camden	65,800	54,800	54,500	73,450	76,700	34,300
Tumbling Creek	Taney	50,000	7,000	-	-	-	20,200
Tunnell	Pulaski	14,600	0	0	-	-	-
Turnback	Lawrence	2,000	-	-	-	-	-
Turner Mill Spring	Oregon	Unknown	-	-	-	4,800	-

\* Due to interchange between Moles and Toby caves, the higher of the two was used to calculate regional and total populations.

\*\* An improved video count method estimated 71,615 gray bats on 14 July 2005.

\*\*\* Great Spirit Cave has experienced a long history of chronic disturbance (R. Clawson, personal communication, 2007).

**Table 6. Current and historical estimates of gray bat populations in Priority 1 Missouri hibernacula (Richard Clawson data, Missouri Department of Conservation, 1 May 2006)**

<b>Coffin Cave, Laclede County</b>	
Winter 2005/2006	– 561,000 gray bats (Richard Clawson survey)
Winter 1984/1985	– 355,450 gray bats (Richard Clawson survey)
Winter 1982/1983	– 349,500 gray bats (Richard Clawson survey)
Winter 1980/1981	– 316,300 gray bats (Richard Clawson survey)
Winter 1978/1979	– 250,000 gray bats (Richard LaVal* survey)
<b>Mose Prater Cave, Shannon County</b>	
Winter 2005/2006	– 155,000 gray bats (Richard Clawson survey)
Winter 2002/2003	– 93,000 gray bats (Mick Sutton** survey)
Winter 1988/1989	– 87,250 gray bats (Richard Clawson survey)
Winter 1984/1985	– 89,450 gray bats (Richard Clawson survey)
Winter 1982/1983	– 112,200 gray bats (Richard Clawson survey)
Winter 1980/1981	– 89,500 gray bats (Richard Clawson survey)
Winter 1975/1976	– 53,900 gray bats (Richard LaVal survey)
<b>Bat Cave, Shannon County</b>	
Winter 2005/2006	– 27,600 gray bats (Richard Clawson survey)
Winter 2004/2005	– 57,000 gray bats (Richard Clawson survey)
Winter 2002/2003	– 41,100 gray bats (Richard Clawson survey)
Winter 2000/2001	– 14,100 gray bats (Richard Clawson survey)
Winter 1998/1999	– 22,400 gray bats (Richard Clawson survey)
Winter 1996/1997	– 36,400 gray bats (Richard Clawson survey)
Winter 1994/1995	– 37,945 gray bats (Richard Clawson survey)
Winter 1992/1993	– 17,030 gray bats (Richard Clawson survey)
Winter 1990/1991	– 46,300 gray bats (Richard Clawson survey)
Winter 1988/1989	– 28,725 gray bats (Richard Clawson survey)
Winter 1986/1987	– 26,050 gray bats (Richard Clawson survey)
Winter 1982/1983	– 24,400 gray bats (Richard Clawson survey)
Winter 1980/1981	– 23,850 gray bats (Richard Clawson survey)
Winter 1979/1980	– 11,500 gray bats (Richard LaVal survey)

\* MDC

\*\* Missouri Cave and Karst Conservancy

## Tennessee

The Gray Bat Recovery Plan (U.S. FWS 1982) lists 54 Priority-1, -2, or -3 gray bat caves in Tennessee (P1=9; P2=25; P3=20). One of the Priority-2 sites is actually a dam that supports roosting bats. Several extensive surveys have been conducted to determine summer and winter populations of gray bats in Tennessee (e.g., Harvey and Pride 1986; Harvey 1992b, 1994; Harvey and Britzke 2002). Gray bats are considered common throughout the cave regions of middle and eastern Tennessee, and recent surveys at both summer and winter caves have shown stable to increasing populations. Table 7 shows selected summer estimates of gray bat populations from 59 Tennessee caves through 2002.

Tennessee caves listed as Priority-1, -2, or -3 were visited and inventoried for the presence of gray bats in 2002. An attempt was made to inventory each cave at least once during the study. Standard techniques and procedures outlined in the Gray Bat Recovery Plan were followed. Hibernating bat numbers were estimated by counting individual bats or by estimating the area in square feet covered by clusters of bats and multiplying by 150-200. Estimates of summer colony size were made by direct observation of bat clusters, measurement of fresh guano deposits, or by estimating the number of bats leaving a cave to forage at dusk (Harvey and Britzke 2002).

In 2002, 38 summer caves were estimated to house a total of 320,930 gray bats, and a count of 631,837 gray bats was estimated in 5 hibernacula (Harvey and Britzke 2002). These estimates compare with 24 gray bat caves estimated to house 318,200 gray bats and 4 hibernation caves estimated to house 299,940 bats during a 1985-86 survey (Harvey and Pride 1986), and 25 bat caves estimated to house 292,509 gray bats during a summer survey in 1994 (Harvey 1994). Significant gray bat caves included Pearson, Nickajack, Bellamy, and Tobaccoport Caves. Pearson Cave (also known as Tunnell Cave) was noted as supporting the second largest known colony of hibernating gray bats, with recent estimates over 365,000. The cave also houses a summer colony of approximately 18,000 gray bats. Bellamy Cave housed a hibernating colony of 139,364 gray bats and a summer population of approximately 35,000. Hubbards Cave supported a hibernating population of over 520,000 gray bats and is considered one of the most important hibernation caves in eastern North America. Nickajack Cave was noted as an important maternity cave, with colonies estimated at 50,000 during 2001-2002. Tobaccoport Cave was an important site for bachelor colonies. Estimates from other maternity caves are provided in Table 7 (Harvey and Britzke 2002).

Results of 2006 summer surveys of selected Tennessee caves are presented in Chapter 6. Several other projects have recently been conducted to improve gray bat caves in the state. Modifications were made to the fence at Nickajack Cave in 2004. A Cooperative Management Agreement with the Southeastern Cave Conservancy, Inc. is nearly finalized for Hound Dog Drop Cave, which houses a summer colony of gray bats, and TNC is working with John Lamb (Arnold AFB), Tennessee Wildlife Resource Agency (TWRA), and the FWS Cookeville Field Office to capture and band gray bats at the Hubbards Cave Preserve (Heather

Garland, TNC, personal communication, 2006). TVA surveyed and made improvements to three cave sites (Norris Dam, Featherfoot, and Nickajack Caves) during 2002-2004 (Henry 2004). Pearson Cave has recently been surveyed and purchased by a private donor (see Chapters 5 and 6).

### Other states

Historically, thousands of gray bats were known to hibernate in Florida in Old Indian Cave (Rice 1955; Lee and Tuttle 1970; Gore 1992). Surveys conducted in the 1980s estimated gray bat populations in Florida at approximately 10,000 bats in summer and a few hundred individuals in winter (Wenner 1984; Gore 1992). Judge's Cave houses the primary gray bat maternity colony, but an accurate census of this population is extremely difficult because the gray bat colony roosts over deep water along with a large colony of southeastern myotis (*Myotis austroriparius*). Disturbance to Old Indian Cave caused gray bats to nearly disappear in the 1970s, and the winter population decreased to only a few hundred individuals in the early 1990s (Gore 1992). The total winter population in Old Indian and Dugong Caves has decreased from 5,000 bats in 1954 to 180 in 1995. Since that time the population has steadily decreased, and no bats were observed in these caves in 2007. Additionally, no gray bats have been documented in maternity caves in the past 5 years (Jeff Gore, Florida Fish and Wildlife Conservation Commission, personal communication, 2007).

**Table 7. Summary of gray bat summer populations in Tennessee in selected years (1986-2002) (from a variety of sources, including Harvey and Pride 1986; Harvey 1992b, 1994; Harvey and Britzke 2002; and unpublished FWS data).**

Cave Name	County	Type	Priority	1986	1994	1999-2000	2001-2002	2006
Alexander Cave	Perry	M	2	6,400	51,000*	-	14,940	11,875
Ament Cave	Putnam	B	2	4,700	1,955	8,330	18,000	
Arch Cave	Green	?	3	-	-	0	-	
Baloney Cave	Knox	T	2	-	-	0	-	
Bat Cave	Hickman	M	2	6,000	2,000*	10,000	-	13,640
Bat Cave	Lincoln	M	2	7,000	21,700*	17,340	-	
Baugus Cave	Decatur	?	3	-	-	100	-	
Bellamy Cave	Montgomery	M, H*	1	35,000	32,800	35,000		84,650
Benderman Cave	Mauzy	B	2	-	-	680	-	
Blowing Cave #1	Perry	S	3	-	-	0	0	
Blythe Ferry Cave	Meigs	B	2	250	6,970	958	-	
Bridgewater Cave	Smith	M, B**	2	10,700	7,140	12,410	-	11,220

Cave Name	County	Type	Priority	1986	1994	1999-2000	2001-2002	2006
Bristol Storm Drain	Sullivan	M		-	-	-	2,500	
Caney Hollow Cave	Franklin	M	2	17,470	9,230	5,000	-	
Coleman Cave	Montgomery	M	3	-	-	-	0	2,375
Cripps Mill Cave	DeKalb	M	1	7,480	3,200	14,450	-	
Dry Cave	Robertson	S	3	-	-	-	100	
Dud's Cave	Jackson	M	2	8,200	8,160	1,360	-	1,500
Espy Cave	Cannon	S		-	-	0	-	
Eves Cave	Meigs	B	2	-	-	-	385	
Featherfoot Cave	Decatur	M	2	2,520	12,000	10,096/20,172	17,232/19,074	
Gallatin Cave	Wilson	S	3	5,000	8,670	3,257/8,682	8,602	
Gin Bluff Cave	DeKalb	B	2	-	-	340	-	
Grassy Creek Cave	Rhea	M	2	16,800	7,500	13,900	-	15,100
Haile Cave	Jackson	M	3	4,700	2,000*	0	-	-
Harris Cave	Rhea	M	2	-	-	0	-	0
Herron Cave	Rutherford	B	2	180	2,720	1,020	1,500	25
Hound Dog Drop Cave	Wayne	S/B		-	-	~ 3,000	-	-
Horner Cave	Hawkins	T	2	**	-	1,000	-	-
Ice Cave	Wayne	S	3	-	-	-	0	
Indian Cave	Grainger	M	1	-	-	5,010	-	6,100
Knowles Ridge Cave	Warren	S/B		-	-	-	25,500	9,400
Lost Creek Cave	Union	S	2	-	-	0	0	
Markham Cave	Clay	B	2	1,680	0	50	-	4
Meredith Cave	Campbell	T	3	-	-	0	-	-
Morrell Cave	Sullivan	S	3	0	10,000	10,000	-	0
New Piper Cave	Smith	S	3	13,100	-	2,140	-	2,975
Nickajack Cave	Marion	M	1	125,000 ?	66,500	25,250/48,949	41,082/54,512	
Norris Dam Cave	Campbell	M	2	0	330	228/4,148	4,430/2,272	
Oaks Cave	Union	M	1	12,200	13,180*	-	5,950	4,120
Only Saltpeter Cave	Hickman	T	3	-	-	0	-	-
Pearson Cave	Hawkins	H*, B**	1	5000 *	2,250*	-	18,500	-
Pennington Cave	Franklin	S	3	-	-	-	0	-
Piper Cave	Smith	M	2	13,100	0	-	0	0
Rattling Pit Cave	Cocke	H*, B**	3	-	-	186	18,000	-
Robinson Cave	Overton	S	3	-	-	0	-	-
Rose Cave	White	M, S^	4	-	-	~ 9,000	-	14,300
Sensabaugh Cave	Meigs	B	2	300	8,840	-	340	-

Cave Name	County	Type	Priority	1986	1994	1999-2000	2001-2002	2006
Short Creek Cave	Perry	T	3	-	-	?	?	-
Station Creek Cave	Claiborne	S	3	-	-	0	-	-
Swallow Bluff Cave	Decatur	S	3	-	-	0	-	-
Tobaccoport Cave	Stewart	H*, B**	1	30	9,600	-	16,500/170	26,885
Trussel Cave	Grady	M	2	2,000	24	1,020	-	-
Unnamed cave	Greene	M	2	-	-	11,250	-	-
Ward Cave	White	S	3	-	-	0	-	-
White Buis Cave	Claiborne	M	1	31,000	4,300	17,000	-	11,020
Woods Dam	Franklin	M	2	500	340	500	-	-
Yell Cave	Bedford	M		-	-	6,300	3,670 ?	-
<p>* Number taken from previous year's survey.  ** Unable to survey cave at this time.  M = Maternity Colony; B = Bachelor Colony; S = Summer Colony; H = Hibernating; T = Transient  S indicates that there was definite evidence of summer gray bat use, but it was not determined if that use was M or B.  ? = Unknown.</p>								

Gray bat colonies have been located in 17 caves in northeastern Oklahoma (Grigsby and Puckette 1982). Eleven Oklahoma caves were surveyed in the early 1990s, seven of which were considered maternity caves, two were alternate maternity sites, and two were transient or bachelor roosts (Grigsby and Smith 1993). Stable or increasing populations were observed at four maternity caves in Oklahoma between 1981 and 1991. Increases in colony size were evident in three of the caves (Grigsby et al. 1993). Martin et al. (2000) reported that populations of four gray bat maternity caves had remained the same or increased between 1981 and 1999 following the installation of internal cave gates.

Gray bats were historically known in Georgia from only individual specimens that were presumed to represent transient individuals. However, Martin and Sneed (1990) reported a summer colony of 4,000 to 9,000 individuals in Lowry Cave in Chattooga Co. Summer surveys conducted in 2007 documented approximately 5,000 gray bats in Frick's Cave, 2,500 in Chickamauga Cave, and 500 in Lowry Cave. Chickamauga Cave supported a maternity colony, whereas the other caves served as bachelor roosts. (Jim Ozier, Georgia Department of Natural Resources, personal communication, 2007). Gray bats were historically known in Mississippi only from a chalk mine located in Tishomingo Co. in the extreme northeastern part of the state (White 1961; LaVal 1967). Sherman

and Martin (2006) reported a gray bat from a site 42 km (26 mi) south of the chalk mine site in 2004, which represents the first gray bat documented for Mississippi in 37 years. At this time gray bats are considered only transient in the state. Illinois and Kansas each contain one maternity colony of gray bats; the Kansas colony occurs in a storm sewer (Hays and Bingham 1964; U.S. FWS 1982).

## **SBDN assessment**

The Southeastern Bat Diversity Network (SBDN) is a regional bat working group that meets annually in conjunction with the “Colloquium on the Conservation of Mammals in the Southeastern United States.” SBDN is composed of biologists from various agencies, organizations, and academia who specialize in bat biology, ecology, and management. In 2000 the Steering Committee of the SBDN met in Miami, FL, and requested that Dr. Michael J. Harvey (Tennessee Tech University) gather current gray bat population data needed to reassess the status of the species. Dr. Harvey reported that the status of the gray bat had apparently improved because numerous important caves had been protected. He further concluded that the species appeared to be one of the most abundant bats within its range. Thus, it was believed that a change in status was appropriate and downlisting would add credibility to the endangered species recovery effort (M. Harvey, personal communication, 2005).

In 2001 at the SBDN Annual Meeting in Memphis, TN, Dr. Harvey and Robert R. Currie, FWS, summarized the recovery progress for the gray bat and the conservation implications of changing the status of the species from Endangered to Threatened. Table 8 provides summary data. Based upon this information, SBDN members passed a resolution supporting this change and directed the SBDN board to send a letter to the FWS recommending that the gray bat be down-listed to Threatened. The Board complied with this resolution (Harvey and Currie 2004). In 2003, the FWS Columbia, Missouri Ecological Services Field Office sent to all states and bat researchers within the range of the gray bat a formal request for updated information on the historic and current status of the species. State agencies, TNC, TVA, and others provided updated information on the gray bat throughout its range in Tennessee.

Harvey and Currie (2004) further reported that the Columbia Field Office, FWS, reviewed the gray bat data and considered submitting a proposal for

down-listing the species to the Regional Office in Twin Cities, MN. However, a review of the 2003 data submitted for review revealed concerns with different techniques used for surveying gray bat populations. Methods used included exit counts at cave entrances, fresh guano measurements, direct observations of adults and young, direct observations of young only, or combinations of these methods. Since methods have not been standardized, direct comparisons of the numbers generated has been difficult. Nevertheless, it appeared that the total range-wide population of the gray bat may be as high as 3.4 million (this compares to the less formal summary presented by the authors at the 2002 SBDN meeting that reported a range-wide population estimate of about 2.7 million). The principal message from this presentation was that the gray bat was doing well and that a reexamination of its status was appropriate (Harvey and Currie 2004).

The status of hibernating populations was further reviewed in 2006 (Harvey and Currie 2007). Table 9 presents summary data from major hibernacula showing that the overall population now totals 3,377,100 bats, an increase of 1,719,200 (104 percent) since listing in 1982. Numbers listed as recent are no more than 4 years old, and most counts were made in the winter of 2005-06. It is particularly impressive that combined counts from Coach Cave, KY, Blanchard Springs Caverns, AR, Cave Mountain Cave, AR, and Bellamy Cave, TN, have increased from a low count total of 430 to a recent total of 744,859 (Harvey and Currie 2007). The Coach Cave low count was 0 in 1995 compared to the 2007 count of 337,750; Blanchard Springs Caverns had a low of 33 in 1985 and a 2006 count of 128,005; 50 bats were recorded in Cave Mountain Cave in 1982 and 139,740 were counted in 2006; and Bellamy cave estimates were 347 in 1965 compared with a recent count of 139,364 in 2006 (M. Harvey, personal communication, 2007). Overall, hibernacula counts have more than doubled since 1982.



Table 8. Review of gray bat population status in selected hibernacula - 2001 data (M. Harvey, unpublished data, 22 February 2001)

Recovery Plan (1982) Estimates compared with 2001 estimates for nine major hibernacula. Total = 1,575,00 (95%) + 82,900 (5%) = 1,657,900 (=1982 estimate)				
State	No. Caves	1982 Plan	Recent	
Alabama	1	700,000	700,000	
Tennessee	3	300,000	288,170	
Arkansas	1	250,000	150,000	
Kentucky	1	25,000	154,500	
Missouri	3	300,000	542,000	
		<b>1,575,000</b>	<b>1,834,640</b>	Up 259,670 (16.5%)
2001 Estimates for 10 Priority-1 Hibernacula Listed in Recovery Plan				
Fern - AL		700,000		
Bonanza - AR		150,000		
Old Indian - FL		100	(not included above)	
Jesse James - KY		154,500		
Coffin - MO		450,000		
Chimney - MO		90,000		
Marvel - MO		2,000		
Pearson - TN		190,000		
Tobaccoport - TN		170		
Hubbards - TN		98,000		
		<b>1,834,770</b>		
2001 Estimates for Additional Hibernacula				
Bat (Shannon Co.) - MO		30,000	(24,400 - 1983)	
Coach - KY		78,000	(0 - 1995)	
Blanchard Springs - AR		81,900	(33 -1985)	
Cave Mountain - AR		172,500	(205 -1988)	
Huffman - AR		38,000	(unknown -1993)	
Still - AR		3,000	(0 - 1980)	
Bellamy - TN		72,250	(347 - 1965)	
Rattling Pit - TN		18,000	(unknown -1995)	
		<b>493,650</b>		
2001 Status Based on Hibernacula Surveys Total 2,328,420 Up 670.520 since 1982 (40%)				

Table 9. Review of gray bat population status in selected hibernacula - 2007 data (M. Harvey and R. Currie, unpublished data, March 2007).

Recovery Plan (1982) Estimate compared with 2006/07 Estimates for Nine Major Hibernacula Total = 1,575,00 (95%) + 82,900 (5%) = 1,657,900 (=1982 estimate)				
State	No. Caves	1982 Plan	Recent	
Alabama	1	700,000	842,300	
Tennessee	3	300,000	798,496	
Arkansas	1	250,000	148,750	
Kentucky	1	25,000	75,150	
Missouri	3	300,000	718,000	
		<b>1,575,000</b>	<b>2,690,887</b>	<b>Up 1,007,696 (64%)</b>
2006/07 Estimates for 10 Priority-1 Hibernacula Listed in Recovery Plan (date surveyed in parenthesis)				
Fern - AL		842,300	(03)	
Bonanza - AR		148,750	(06)	
Old Indian - FL		100?	(not included above)	
Jesse James - KY		75,150	(07)	
Coffin - MO		561,000	(06)	
Chimney - MO		155,000	(06)	
Marvel - MO		2,000	??	
Pearson - TN		278,000	(07)	
Tobaccoport - TN		170	??	
Hubbards - TN		520,326	(06)	
		<b>2,582,796</b>		
Estimates for Additional Hibernacula (Recent)				
Bat (Shannon Co.) - MO		27,600 (06)	(24,400 - 1983)	
Coach - KY		337,750 (07)	(0 - 1995)	
Blanchard Springs - AR		128,005 (06)	(33 -1985)	
Cave Mountain - AR		139,740 (06)	(205 -1988)	
Huffman - AR		~3,500 (05)	(unknown -1993)	
Still - AR		345 (06)	(0 - 1980)	
Bellamy - TN		139,364 (06)	(347 - 1965)	
Rattling Pit - TN		18,000 (02)	(unknown -1995)	
		<b>794,304</b>		
<b>Total 3,377,100 Up 1,719,200 since 1982 (104%)</b>				

## 5 2005-2007 Hibernacula Surveys

A multi-agency working group was convened in 2005 to examine the current status of the gray bat and determine actions that were needed to consider recovery of the species. Protection of critical hibernacula was considered one of the most critical steps to accomplish recovery. A major obstacle preventing a determination of the status of the gray bat was the absence of data from a recent range-wide survey of wintering populations at major hibernacula. Agency personnel examined information from known hibernacula and prioritized caves that were considered critical for long-term protection of the species. The 12 caves listed below were identified as priority caves for inclusion in 2005/2006 hibernacula surveys based on input from the FWS, BCI, and state agency personnel. The survey represents a coordinated effort among the FWS, U.S. Army Research and Development Center (ERDC), U.S. Forest Service (USFS), TVA, BCI, TNC, and the states of Missouri, Arkansas, Tennessee, Alabama, and Kentucky. The Arkansas Game and Fish Commission fully funded their work during the survey period. Robert Currie, FWS Asheville Field Office, scheduled and coordinated the cave surveys and reported results to ERDC.

- Bellamy Cave, TN
- Hubbards Cave, TN
- Pearson Cave, TN
- Blanchard Spring Caverns, AR
- Bonanza Cave, AR
- Cave Mountain Cave, AR
- Coffin Cave, MO
- Mose Prater Cave, MO
- Bat Cave (Shannon Co.), MO
- Coach Cave, KY
- Jesse James Cave, KY
- Fern Cave, AL

Gray bat surveys were conducted in major hibernating caves in Tennessee, Missouri, and Arkansas during the 2005-2006 wintering period. Results of these surveys are presented below. The current status of Kentucky and Alabama caves is also discussed.

## **Tennessee**

Surveys were conducted in Bellamy and Hubbards Caves, TN on 10-11 January 2006. Population counts were made by Dr. Merlin Tuttle, Jim Kennedy, and Kari Gaukler, BCI, and Heather Garland, TNC. Personnel with the TWRA also attended the survey of Hubbards Cave. The team had planned to visit Pearson Cave during this period but was denied access by the property owner. However, permission was granted to survey Pearson Cave in February 2007. The total combined count for these caves was 938,047.

### **Bellamy Cave**

The survey of Bellamy Cave documented 139,364 hibernating gray bats. Independent counts by Tuttle and Garland ranged from 137,525 (Garland) to 141,203 (Tuttle), a difference of 2.6 percent. These numbers were averaged to obtain the final estimate of 139,624. This represented a 53 percent increase from the last census in 2003 when 91,100 bats were counted, suggesting an average annual increase of 13.25 percent. Approximately 200 Indiana bats also were observed in Bellamy Cave, which were the first documented for this cave in many years (Tuttle and Kennedy 2006).

### **Hubbards Cave**

The survey of Hubbards Cave resulted in an estimate of 520,326 gray bats (average of independent counts). Independent counts were 550,430 (Garland) and 490,222 (Tuttle). The estimate is a 232 percent increase from the last census in 2002, indicating an average annual increase of 58 percent. Hubbards Cave has historically been heavily disturbed and vandalized, and by the mid-1960s only a few thousand gray bats could be found. In 1968 approximately 250,000 gray bats were discovered in low sections of the cave. Figure 5 shows gray bats roosting along the walls of Hubbards and Bellamy Caves.



Figure 5. Gray bats hibernate along the walls and ceiling of Hubbards Cave (above) and Bellamy Cave (below), January 2006 (photographs courtesy of M. Tuttle and J. Kennedy, BCI).

### **Pearson Cave**

The survey team was unable to survey Pearson Cave in 2006 due to refusal of access, but representatives of FWS and BCI continued to negotiate with the landowner and permission was finally granted to conduct surveys in 2007. Tuttle (1976a) conducted wintering bat surveys in the cave from 1959 through 1976, during which time counts ranged from 80,000 to 125,000. The primary entrance was gated in 1989 through a collaborative project involving The Nature Conservancy of Tennessee, BCI, the American Cave Conservation Association, and FWS (Tuttle and Kennedy 2002). The cave's gray bat population had grown rapidly to an estimated 365,841 by 2002 (Figure 6), a nearly fourfold increase from the previous count, and Tuttle and Kennedy (2006) speculated that the population could potentially be in excess of 500,000 bats. Pearson Cave is considered to provide the most optimal temperature range for gray bat hibernation of any cave within the species' range.

On 4 February 2007 all accessible roosting areas in Pearson Cave were recorded, and all major roosts were independently and simultaneously surveyed by Merlin Tuttle (BCI) and Heather Garland (TNC), accompanied by Robert Currie (FWS) and Dave Waldien (BCI). The sampling protocol is described in Tuttle (2007). The total estimate for combined and averaged counts (by Tuttle and Garland) was 278,357 gray bats. However, a recording error was identified that apparently led to an underestimate of a large cluster of bats (Tuttle 2007). So, the estimated decline from 365,841 bats in 2002 to 278,357 in 2007 probably does not represent a true population decline. Pearson Cave is very complex and bats roost in widely varying densities on highly irregular surfaces, sometimes high above floors. Unknown numbers are able to roost where they may not be detected (Tuttle 2007). The 2007 counts were obviously conservative, likely reduced by over 70,000 due to the failure of one of the observers to detect some remote clusters; therefore, the hibernating population of gray bats in Pearson Cave is considered at least stable (Tuttle 2007).

### **Arkansas**

Surveys of Blanchard Springs Caverns, Bonanza Cave, and Cave Mountain Cave, AR were conducted by Dr. Michael J. Harvey, Ron Redman, Dr. Eric Britzke, and Blake Sasse on 21 January 2006. The total combined count for these caves was 416,495 gray bats.





Figure 6. Survey of hibernating gray bats in Pearson Cave, TN, 2002 (Photograph courtesy of M. Tuttle, BCI).

**Blanchard Springs Caverns**

The January 2006 Blanchard Springs Caverns count was 128,005 gray bats. The 1985-86 winter counts at Blanchard Springs Caverns had dropped to a low of 33 gray bats, from a previous high of 5,000 to 6,000 bats. Since that winter, the USFS has limited disturbance to the roost site.

**Bonanza Cave**

The 2006 count for Bonanza Cave was 148,750 gray bats. During the winter of 1998-99 a large portion of the bluff above Bonanza Cave collapsed, partially blocking the entrance and destroying the gate. The 2001-02 winter count at Bonanza Cave was 55,000 gray bats; the previous high was 250,000. The cave was re-gated by the USFS during the summer of 2002.

**Cave Mountain Cave**

The January 2006 Cave Mountain gray bat count was 139,740. Historically, the 1981-82 winter count at Cave Mountain Cave was 50 gray bats, and no more than 700 gray bats had ever been reported from the cave. During the winter of 2004-05 vandals entered the cave during the hibernation period and killed approximately 200 gray bats with a shotgun; no arrests have ever been made (B. Sasse, personal communication, 2006). The cave was fenced by the National Park Service during the summer of 1982.

**Missouri**

Mid-winter surveys were conducted at three Missouri caves (Coffin, Mose Prater, and Bat Caves) in 2005-2006. The surveys were conducted by Richard Clawson, MDC, and Bob Currie, FWS. Assistance was provided by Bill Elliot, Jim Kaufman, Rita Worden, and Peggy Horner (MDC) and Scott House and George Bilbrey (Cave Research Foundation). The total combined count of gray bats for these caves was 743,600.

**Coffin Cave**

Coffin Cave, Laclade Co., was surveyed on 24 January 2006. The survey resulted in an estimate of 561,000 gray bats. This was compared to 355,450 estimated during the last count in 1984/1985. Approximately 250,000 gray bats were reported during a 1978/1979 survey. Other previous counts were 316,300 in 1980/1981 and 349,500 in 1982/1983 (R. Clawson, personal communication, 2006).



**Mose Prater Cave**

An estimate of 155,000 resulted from the survey of Mose Prater Cave, Shannon Co. on 25 January 2006. This compared to 93,000 during the last count in 2002/2003. The lowest count was 53,900 in 1975/1976. Other counts ranged from 89,500 in 1980/1981 to 112,200 in 1982/1983 (R. Clawson, personal communication, 2006).

**Bat Cave**

A count of 27,600 gray bats was estimated for Bat Cave, Shannon Co. on 25 January 2006. This represented a decrease from 57,850 in 2004/2005. Since 1974/1975, winter counts have ranged from approximately 11,500 to 46,000, with considerable variation from year to year (R. Clawson, personal communication, 2006).

**Kentucky****Coach/Jesse James Caves**

Coach and Jesse James Caves were surveyed in 2003. Coach Cave was also surveyed in 2005, but it was impossible to get a count in Jesse James because of damage to steps leading to the lower section of the cave that supports the hibernation colony (Traci Hemberger, personal communication, 2006). The 2005 estimate for Coach Cave was over 260,000 bats. The rotten steps in James Cave were removed in the summer of 2006, and surveys of both caves were conducted on 25 January 2007 by Traci Hemberger, John MacGregor (KDFWR), and Robert Currie. Gray bat estimates were 75,150 in James Cave and 337,900 in Coach Cave, for a total of 412,900 bats at the combined hibernation sites (R. Currie, personal communication, 2007).

**Alabama****Fern Cave**

The single Alabama cave (Fern Cave) houses the largest known gray bat hibernating population. During the most recent survey in 2003, estimates ranged from 413,600 to 1,271,000, averaging 842,300 (Tuttle and Kennedy 2006).

## **6 DOD/Army Initiatives**

### **DOD Legacy Project**

#### **Project Development**

It was the general consensus of gray bat experts gathered in August 2005 that the population of gray bats has recovered across the range of the species. The two main obstacles preventing consensus that the species is recovered were lack of a recent, range-wide survey of major populations, and lack of an accepted inventory and monitoring protocol (the ESA requires a species to be monitored for 5 years following de-listing). In addition, the assembled experts felt that certain other conservation actions were necessary to fully meet recovery plan goals. Therefore, a proposal was submitted in 2005 to the DOD Legacy Program to assist with the gray bat recovery effort. The Legacy project is titled “Conserve Gray Bat to Achieve Recovery.” The proposal was approved in March 2006. This project engaged numerous partners and their assets to complete conservation efforts identified as needed to recover the gray bat. The following tasks were approved and funded for the Legacy project; funds were provided to the FWS for distribution:

- Provide an improved gate for Bellamy Cave, TN
- Secure protection of Pearson Cave, TN
- Repair access steps to Jesse James Cave, KY
- Survey 5-10 maternity caves in Tennessee
- Hibernacula surveys of 9 caves in Missouri, Tennessee, and Arkansas

Additionally, this report will serve as a Technical Report for the Legacy project and a Fact Sheet will be prepared. Hibernacula surveys were conducted using Research and Development funds provided by the ERDC. Partners involved in the overall effort include BCI, TNC, FWS, U.S. Army, FS, TVA, Tennessee Tech University, Tennessee Wildlife Resource Agency, MDC, and Arkansas Game and Fish Commission (AGFC). As previously noted AGFC fully funded their own work as part of the survey. A gray bat planning meeting was held 21 March 2006 during the North American Wildlife and Natural Resources Conference in Columbus, OH. The purpose of the meeting was to clarify components of the Legacy project and assign responsibility for action items.

### Status of deliverables

Hibernacula surveys have been completed, and results are provided in this report. A total of 2,511,042 bats were estimated for 11 caves surveyed (Bellamy, Hubbards, Pearson Caves, TN; Blanchard Springs Caverns, Bonanza Cave, and Cave Mountain Cave, AR; Coffin, Mose Prater, and Bat Caves, MO; and Coach and Jesse James Caves, KY. Fern Cave, AL, could not be surveyed due to hazardous conditions. Access was not granted to Pearson Cave during the initial 2006 survey period, but the land owner subsequently allowed access in January 2007 (Figure 7), and the cave was surveyed in February. Additionally, the land owner agreed to sell the cave and associated property, which consists of 41 ha (101 acres), with approximately 20.2 ha (50 acres) in woodland and the rest in overgrown pasture. Subsequently, a private donor working with TNC purchased the cave. The State of Tennessee then submitted a proposal to the FWS under the Endangered Species Act, Section 6 Recovery Land Acquisition Grant Program to approve acquisition of the site. The grant was not approved for Fiscal Year (FY) 2007 funding. However, the grant request will be resubmitted by the state in FY 2008 and it is expected that it will then be funded. The private donor is willing to hold the property for the state until they receive funding to purchase the cave (R. Currie, personal communication, 2007).

The FWS coordinated with TNC, TVA, and other agency personnel to develop a list of Tennessee caves to be surveyed during the spring and summer of 2006. These included 24 caves surveyed using Legacy funds (a considerable increase over the number of sites originally designated) and 11 caves surveyed through other sources (Table 10). Heather Garland, Tennessee Chapter of TNC, assumed the responsibility of ensuring that the Legacy surveys were conducted and coordinated the work with the FWS. Table 11 summarizes data from the 24 caves that were selected for survey during the summer of 2006 (Britzke and Redman 2006). Researchers used mainly direct observation to estimate numbers of bats exiting the caves; night vision equipment was used to assist counts at some caves. Bats were counted as they emerged, and counting continued until no bats were observed leaving the roost. After all bats had exited, the cave was entered to determine if the site supported a bachelor colony or a maternity colony. The colony type was determined primarily by the presence of young bats in the cave. Cave floors were searched for evidence of dead bats at sites where the young had become volant. A total of 201,563 bats was counted exiting 21 caves; several caves could not be surveyed due to lack of

permission or access. Also, determination of the type of colony present was difficult for some caves (Britzke and Redman 2006).



Figure 7. Pearson Cave gated entrance, January 2007 (photograph courtesy R. Currie, FWS).

**Table 10. Tennessee Caves scheduled for gray bat surveys during spring/summer of 2006.**  
**Surveys funded through the DOD Legacy Program and through other sources are shown**  
**separately (information provided by FWS 2006)**

<b>Cave</b>	<b>County</b>	<b>Protection Priority</b>	<b>Type</b>
White Buis Cave	Claiborne	1	M
Cripps Mill/Goat Cave	DeKalb	1	M
Indian Cave	Grainger	1	M
Bellamy Cave	Montgomery	1	M
Tobaccoport Cave	Stewart	1	B/M
Oaks Cave	Union	1	M
Pearson Cave	Hawkins	1	B
Bat Cave	Hickman	2	M
Dud's Cave	Jackson	2	M
Bat Cave	Lincoln	2	M
Alexander Cave	Perry	2	M
Grassy Creek Cave	Rhea	2	M
Harris Cave	Rhea	2	M
Herron Cave	Rutherford	2	B/?
Bridgewater Cave	Smith	2	M
Piper Cave	Smith	2	M
New Piper Cave	Smith	3	S
Haile Cave	Jackson	3	M
Coleman Cave	Montgomery	3	M
Morrell Cave	Sullivan	3	S
Rose Cave	White	4	M, S
Hound Dog Drop Cave	Wayne		B
Knowles Ridge Cave	Warren		B
Markham Cave	Clay	2	B
<b>Other Sources</b>			
Nickajack Cave	Marion	1	M
Norris Dam Cave	Campbell	2	M
Featherfoot Cave	Decatur	2	M
Blythe Ferry Cave	Meigs	2	B
Gallatin Cave	Wilson	3	B
Unnamed Cave	Greene		M
Wood's Dam	Franklin	2	M
Caney Hollow Cave	Franklin	2	M
Trussel Cave	Grundy	2	M/?
Yell Cave	Bedford		M
Ament Cave	Putnam	2	M
M = Maternity Colony; B = Bachelor Colony; S = Summer Colony; ? = Undetermined S indicates that there was definite evidence of summer gray bat use, but it was not determined if that was M or B.			

**Table 11. Survey results of 24 known gray bat summer caves in Tennessee during 2006 (Britzke and Redman 2006).**

Cave	County	Date	# of bats	Colony Type	Notes
Alexander Cave	Perry	7/17/06	11,875	Maternity	Dead juveniles found in guano pile
Bat Cave	Hickman	7/18/06	13,640	Maternity	Dead juveniles found in guano pile
Bat Cave	Lincoln				Landowner could not be contacted
Bellamy	Montgomery	6/21/06	84,650	Unknown	No bats observed during trip through cave
Bridgewater	Smith	7/6/06	11,220	Maternity	Dead juveniles found in guano pile
Coleman Cave	Montgomery	6/22/06	2,375	Maternity	Juveniles observed in cave
Cripps Mill/Goat Cave	DeKalb	6/24/06	N/A	N/A	Landowner denied access
Dud's Cave	Jackson	6/24/06	1,500	Maternity	Juveniles observed in cave
Grassy Creek Cave	Rhea	6/14/06	15,100	Unknown	Cave not entered
Haile Cave	Jackson	6/24/06	0	N/A	
Harris Cave	Rhea	6/14/06	0	N/A	
Herron Cave	Rutherford	6/15/06	25	Unknown	Cave not entered
Hound Dog Drop Cave	Wayne				Permission was not obtained in time for this study
Indian Cave	Grainger	6/10/06	6,100	Maternity	Dead juveniles found in guano pile
Knowles Ridge Cave	Warren	7/7/06	9,400	Unknown	
Marcom	Clay	7/7/06	4	Unknown	Landowner stated bats were present in fall and spring
Morrell Cave	Sullivan	6/13/06	0	N/A	Cave entered during the day based on info from owner
New Piper Cave	Smith	7/6/06	2,975	Unknown	No dead juveniles noted
Oaks Cave	Union	6/12/06	4,120	Unknown	No bats observed during trip through cave
Pearson Cave	Hawkins				Landowner denied access
Piper Cave	Smith	7/6/06	0	N/A	
Rose Cave	White	7/12/06	14,300	Maternity	Dead juveniles found in guano pile
Tobaccoport Cave	Stewart	6/20/06	26,885	Unknown	Cave not entered, roost site is inaccessible
White Buis Cave	Clairborne	6/11/06	11,020	Maternity	Dead juveniles found in guano pile

Experimental thermal imaging techniques were also applied to several of the 24 Tennessee caves surveyed during the summer of 2006. Thermal imaging performed simultaneous with the Britzke and Redman (2006) direct counts were conducted at Bellamy, Alexander, Herron, and Tobaccoport Caves. Imaging was conducted at Coleman and Oaks Caves on dates that were not simultaneous with the direct counts. Other caves

imaged but not included in direct counts were Trussel Cave, TN; Little Bat Cave, TN; Cave Hollow, TN; Galatin Steam Plant Cave, TN; Caney Branch Cave, KY; Jones Cave, KY; and Boones Cave, KY. Results from these surveys will be reported at a later date (Bruce Sabol, ERDC-EL, personal communication, 2007).

Bellamy Cave protection has been completed. Data loggers have been installed in the cave, and roost site temperatures are being monitored. TNC collaborated with a local cave surveying team to produce an accurate map of the system. The team initially expected to complete the work in September 2006, but a previously unknown passageway was discovered that had a large roosting colony of gray bats. Additionally, numerous large roost sites were located, including one section where the entire floor was covered in foot-deep guano. The survey team suspended the project until the spring of 2007 so as not to disturb the hibernating colony (H. Garland, personal communication, 2006). The temperature study has been completed and a new fence was installed in June 2007. The cave survey work has been finished, and cartographers are preparing a detailed map of the entire Bellamy Cave system (Cory Holliday, TNC, 2007). Also, an improved gate was installed at the entrance to Hubbards Cave during May 2006 (Figure 8).

The Jesse James Cave portion of the Legacy Gray Bat Project was completed over the Labor Day weekend in 2006. All of the rotten stairs, landings, and walkways were cut into small pieces during two previous work weekends, and on 2 September all of these materials were hauled out of the cave and placed in a dumpster for proper disposal. Approximately 40 volunteers contributed to the project. The Coach and James Mapping Group, American Cave Conservation Association, Kentucky Department of Fish and Wildlife Resources, and FWS all participated in the work. The Mapping Group took the lead on the project and did all of the work leading up to the final day. The Army Endangered Species Research Program provided support through supplemental funding. The project was successful and researchers were able to conduct a gray bat survey of Jesse James Cave during the winter of 2006/07 (R. Currie, personal communication, 2007).





Figure 8. Hubbards Cave gate replacement in May 2006 (photo courtesy of J. Kennedy, BCI).

## Army research efforts

The Army Endangered Species Research Program is sponsoring several additional studies that will serve to supplement existing information regarding the status of gray bat populations. These studies are summarized in the following paragraphs.

### Development of census techniques using digital image processing

Accurately censusing colonial bats during emergence from caves is important to monitoring population trends for many species. Video imaging using night vision imagers creates a permanent record that can be analyzed in a laboratory setting. Although this approach improves counting accuracy compared to unassisted observation counts (i.e., attempts at enumerating emerging bats with the naked eye), it is still very time intensive. Thus, the Army is undertaking research to improve data analysis by applying an automated detection and tracking program to several types of video imagery (Figure 9). This work is led by Bruce Sabol. The primary objectives of the research are:



1. Complete development of a digital image processing software system capable of detecting, tracking, and enumerating bats from and to a roost site;
2. Test and modify the software to accommodate use of low-cost illuminated near-infrared or light-intensified cameras in addition to TIR imagers;
3. Conduct surveys in cooperation with the FWS to compare the new image analysis technique with established census techniques at priority gray bat roost sites; and
4. Generate software and user guidance documentation for use of the methodology, and prepare manuscripts for peer-reviewed journals describing the results of the Army research.



Figure 9. Thermal imagery is being tested as an improved method for making gray bat exit counts.

In 2005 researchers from the Army accompanied FWS personnel in conducting test and evaluation activities of this technology at gray bat caves in Alabama, Tennessee, Kentucky, Missouri, and Arkansas. At each site, this team was joined by local resource agency personnel who routinely monitor the caves. The data collected during these trips permitted comparison of a variety of techniques for censusing gray bats. Results from this data collection effort revealed that there was significant difference

between emergence counts made by trained observers and emergence counts using digitally processed imagery (B. Sabol, personal communication, 2006). Documentation of the software for analysis of thermal imagery is now complete, and documentation of the software for analysis of near-infrared imagery is in the final stages of development. The technology was briefed to 150 people at the Southeastern Bat Diversity Network Annual Meeting on 17 February 2006, and a number of field biologists are prepared to deploy this tool when it is available. Field validation was performed in 2006 (B. Sabol, personal communication, 2006).

### **Assessment of intercolony genetic structuring**

Knowing the identity of winter hibernation roosts used by gray bats that summer in caves on Army installations is an important element in the development of comprehensive management plans for this species. While extensive banding studies were conducted for gray bats in the past (through the 1970s), changes in migration patterns since that time are largely undocumented. Depending on the degree of genetic differentiation among hibernating colonies, genetic markers (namely multilocus microsatellite deoxyribonucleic acid (DNA) genotypes) may be a possible tool for use in assigning maternity colonies to winter hibernacula. Three primary tasks must be addressed in order to determine potential utility of DNA markers to identify summer-winter roost relationships in gray bats (R. Lance, personal communication, 2006):

1. Identify adequate genetic markers for tests of genetic differentiation among hibernacula populations,
2. Determine the extent of genetic differentiation among hibernacula populations, and
3. Estimate the predictive power of selected genetic markers to “assign” individual gray bats from summer populations to different hibernacula populations.

DNA samples from bat fecal pellets have been collected from across the species range in Arkansas, Kentucky, and Missouri. Forty-one different microsatellite loci have been under evaluation, and 8 micro-satellite loci have been identified as promising, with 11 eliminated from further consideration. Work has begun on obtaining microsatellite genotypes from fecal pellet samples. Initial analyses had mixed results, and other genetic analysis techniques will be used. Researchers may also consider using

mitochondrial DNA markers if necessary. If research identifies genetic differentiation from hibernacula across the range, this technique will be applied in an attempt to identify hibernacula used by summer maternity colonies found in caves on Fort Leonard Wood, MO (R. Lance, personal communication, 2006).

## 7 Summary and Discussion

The U.S. Army has documented the presence of gray bats at seven installations in five states: Fort McClellan Army National Guard Training Center and Redstone Arsenal, AL; Indiana AAP, IN; Forts Campbell and Knox, KY; Fort Leonard Wood, MO; and Holston AAP, TN. A maternity population is additionally known at Arnold AFB, TN. All installations where gray bats are known to occur provide suitable foraging habitat for gray bats and other bat species. In most cases INRMPs included TES components that provided for management and improvement of wetlands, riparian areas, and other foraging habitats.

Fort Knox and Fort Leonard Wood were the only Army installations that documented caves that serve as gray bat roosting habitat. Fort Knox caves are presently used only as transitional roosts during migration between summer and winter habitats, and during foraging trips from primary summer caves (BHE Environmental, Inc. 2001). Several Fort Leonard Wood caves provide gray bat roosting habitat. A maternity colony consisting of from 3,000 to 5,000 gray bats uses Saltpeter No. 3 Cave on Fort Leonard Wood, and Freeman Cave is used by transient gray bats during migration. Several Indiana bat caves are also on Fort Leonard Wood where small numbers of gray bats occasionally reside during winter. Known gray bat caves on both installations are protected by a combination of enforcement signs, fences, and/or gates. Additionally, Fort Leonard Wood has established buffers around caves and maintains general control of all activities within a broad protective zone.

All seven installations with documented occurrence of gray bats have implemented practices to reduce the use of pesticides in the vicinity of roosts and foraging areas. The Army is participating in a DOD initiative to reduce pesticide applications on installations. The Army has reported pounds of active ingredient (PAI) applied annually since the baseline year 1993 (Bill Woodson, HQDA, personal communication, 2006). The latest figures show that the PAI applied on six of the subject installations has been cut by over 13,000 PAI per year (33,195 PAI in 1993 to 19,868 PAI in 2005). Current data are not available for Fort McClellan, but records show that the PAI for this installation decreased from 1,365 in 1993 to 370 PAI in 1997.

Population data for the gray bat were obtained through various sources, including published literature, state and contract reports, and personal communication with bat researchers and resource managers. Historical population estimates were reviewed for maternal colonies and hibernacula. Gray bat population survey data were obtained from the states of Alabama, Arkansas, Kentucky, Missouri, and Tennessee. General summary information from these states is provided in the following paragraph.

Recent Alabama surveys indicated that gray bat numbers have generally remained stable in most of the major caves surveyed (Hudson 2004, 2005). The June 2005 estimate for Sauta Cave, which houses the largest summer colony of gray bats, was 452,900. Fern Cave is the largest hibernaculum in Alabama, but counts are extremely difficult due to treacherous access and dispersal of bats in the cave. An estimated 180,000+ gray bats are known to inhabit approximately 20 Arkansas maternity and bachelor caves during the summer, and approximately 350,000+ hibernate in five Arkansas caves during the winter. The Arkansas gray bat population appears to be relatively stable, and possibly increasing (Harvey et al. 2005). In Kentucky, counts have fluctuated considerably among years, but the general trend indicates a stable to increasing population for most sites; hibernacula data show a substantial upward trend in the wintering bat populations of Priority-1 caves (T. Hemberger, personal communication, 2006). The total population of 52 maternity colonies in Missouri has increased from 456,100 in 1980 to 794,010 in 2004. Estimates from major hibernacula have increased from approximately 315,000 in the mid-1970s to 743,600 during 2005/2006 winter surveys (R. Clawson, personal communication, 2006). Gray bats are considered common throughout the cave regions of middle and eastern Tennessee, and recent surveys of maternity colonies and hibernacula have shown stable to increasing populations. In 2002 summer caves in Tennessee were estimated to house 320,930 gray bats, and a count of 631,837 was estimated in 5 hibernacula (Harvey and Britzke 2002).

Data from recent surveys revealed that gray bat populations have increased substantially throughout the species range, which resulted in a recommendation for reviewing the status of the species (submitted to the FWS by the SBDN in 2001). At the time of publication of the Recovery Plan (U.S. FWS 1982), the population was estimated at 1,657,900 across

its range. In 2002, the total population was estimated at 2,678,137, an increase of 62 percent from the time the plan was written (Harvey and Britzke 2002; Ellison et al. 2003). This dramatic increase in population size resulted in a formal request to the FWS to review the Endangered Species status of the gray bat. This was further supported by more recent data suggesting that the total range-wide population may be as high as 3.4 million (M. Harvey, personal communication, 2006).

During the winters of 2005-2006 and 2006-2007 a team of scientists representing the FWS, ERDC, BCI, TNC, Tennessee Tech University, and the states of Tennessee, Arkansas, Missouri, and Kentucky surveyed selected caves known to house significant populations of gray bats. Results of these surveys are summarized below.

In Bellamy Cave, TN, the gray bat has recovered from only 65 individuals at the time of listing in the 1970s to its current population of over 139,000, estimated during 2005-06 hibernacula surveys (Tuttle and Kennedy 2006). The population estimate for the previous winter count in 2002 was 91,000. The cave and 12.1 ha (30 acres) of surface property were purchased by the Nature Conservancy in 2005; these properties were turned over to the Tennessee Wildlife Resources Agency in 2006. The population in Bellamy Cave appears to be increasing, but Tuttle and Kennedy (2006) suggested that it was unlikely that the population would indefinitely continue its rapid growth because of higher than desirable hibernation roost temperatures. During the 2005-06 survey, a small sink hole entrance adjacent to the protected property was noted. Tuttle and Kennedy (2006) stated that this adjacent area should be monitored because changes to the entrance could affect air flow and temperatures in the main portion of the cave.

The Hubbards Cave 2005-06 population estimate was 520,326, compared with 156,726 during the 2002 survey. Historically Hubbards Cave has been heavily visited and vandalized. By the mid-1960s only a few thousand gray bats could be located in areas accessible to humans. Raccoons (*Procyon lotor*) had also preyed heavily on bats that were forced to roost at lower elevations than desirable. Human disturbance has been eliminated in the cave and bats are now able to utilize colder, more elevated sites near the entrance. Tuttle and Kennedy (2006) stated that the potential is real for this population to exceed a million gray bats within the next 10 years. TNC

has provided long-term protection for Hubbards Cave; one of the three protective gates at the cave had deteriorated and was replaced in 2006.

Pearson Cave was not surveyed in 2006 due to refusal of access by the landowner, but permission was finally granted to survey the cave in February 2007. The 2007 Pearson Cave population estimate was 278,357 gray bats, compared to 365,841 in 2002. However, Tuttle (2007) documented a recording error that apparently resulted in an underestimate of over 70,000 bats for the 2007 survey. Recent counts reflect a significant increase in wintering populations compared to historical estimates of 80,000 to 125,000 gray bats during 1959-1976 surveys (Tuttle 1976a). A protective gate was installed at the main entrance of the cave in 1989, and a new lock was provided in 2002 (Tuttle and Kennedy 2006). The gate was found to be locked and secure during an inspection in December 2006 (R. Currie, personal communication, 2007). In 2007 Pearson Cave was purchased from the previous landowner by a private donor working with TNC and will ultimately become the property of TWRA.

An estimated 180,000+ gray bats are known to inhabit approximately 20 Arkansas maternity and bachelor caves during the summer, while approximately 350,000+ hibernate in five Arkansas caves during the winter (Harvey et al. 2005). The difference between estimated Arkansas summer and winter populations occurs in part because many gray bats that hibernate in Arkansas are known to migrate to summer caves in nearby states. Also, some gray bats that hibernate in Missouri caves are known to summer in Arkansas caves. Harvey et al. (2005) noted considerable variation in the Bonanza Cave hibernating population, and stated that estimates were difficult because of the cave configuration and collapse of a portion of the bluff above the cave entrance during the winter of 1998-99. The usual estimate in Bonanza Cave until recently was 250,000, but the population decreased to 55,000 during February 2002. However, an estimated 107,710 gray bats were observed hibernating in the cave in 2003-04 (Harvey et al. 2005). The 2005-06 winter survey resulted in an estimate of 148,750, suggesting a stable to increasing population at the site. Winter populations in Blanchard Springs Caverns and Cave Mountain Cave have shown significant increases in recent years. The 2006 Blanchard Springs Caverns estimate was 128,005, compared with only 33 in 1985, and the Cave Mountain Cave population increased from 50 in 1982 to 139,740 in 2006.

Mid-winter surveys were conducted in Coffin, Mose Prater, and Bat Caves, MO, in January 2006. The total combined count of gray bats for these caves was 743,600. The Coffin Cave estimate of 561,000 gray bats compared to 355,450 bats in 1984/1985. The 2006 Mose Prater Cave gray bat estimate was 155,000 compared with 93,000 in 2002/2003. Bat Cave was the only site showing a decrease; the population estimate in 2006 was 27,600 compared to 57,850 in 2004/2005. Priority-1 Kentucky caves were surveyed in January 2007. Gray bat estimates were 75,150 for Jesse James Cave and 337,750 for Coach Cave, for a total count of 412,900.

The total gray bat population appears to have increased significantly since listing in 1982. With current census information, Harvey and Britzke (2002) asserted that a majority of important gray bat caves have been protected and that intensive management for the species may no longer be required. Populations at major caves should be monitored periodically, however, as recommended in the Gray Bat Recovery Plan. Data from the 2005-2006 hibernacula surveys support that recommendation.

In 2005 a proposal was submitted to the DOD Legacy Program to assist with the gray bat recovery effort. The project was approved and funds were provided to the FWS to accomplish the following tasks:

1. Provide an improved gate for Bellamy Cave, TN
2. Secure protection of Pearson Cave, TN
3. Repair access steps to Jesse James Cave, KY
4. Survey 5-10 maternity caves in Tennessee
5. Conduct hibernacula surveys of 9 caves in Missouri, Tennessee, and Arkansas

The project engaged numerous partners and their assets to complete the assigned tasks. All critical elements of the project have been completed. Hibernacula surveys for 2005-06 were completed for eight caves in Tennessee, Arkansas, and Missouri. Three additional caves in Tennessee and Kentucky were surveyed in 2007. One cave in Alabama could not be surveyed due to hazards. Improvements of Jesse James Cave have been completed, Bellamy Cave has been refenced, and surveys have been completed for selected maternity caves in Tennessee. A fence rather than a traditional cave gate was chosen for Bellamy Cave because of the small size of the entrance relative to the large numbers of bats navigating in and out of the cave (Garland 2007).



## 8 Conclusions

The gray bat was federally listed as an Endangered Species in 1976 due to a range-wide population decline. The major cause of this decline was human disturbance of caves, and the primary recovery action identified in the Gray Bat Recovery Plan (U.S. FWS 1982) was to provide protection for important gray bat caves. In the intervening 24 years, much progress has been made to provide permanent protection of gray bat caves throughout the species' range. Numerous maternity caves have been protected, and all of the key winter hibernacula have been secured.

The seven Army installations with gray bats documented on-site have developed management plans for the gray bat and have actively pursued conservation efforts to benefit the species. Management actions consist of riparian area protection/enhancement and protection of caves. The Army has also made significant advances in maternity cave census techniques using infrared image processing. This technology has been developed in close cooperation with the FWS and is presently undergoing field testing at selected field sites across the species' range.

Recent and historical data were obtained through coordination with state nongame and endangered species experts. Detailed survey data for maternity colonies and hibernacula were summarized for the states of Alabama, Arkansas, Kentucky, Missouri, and Tennessee. State records showed stable to increasing populations of gray bats throughout the species' range.

The U.S. Army joined with the FWS and several other agencies and organizations to undertake a range-wide survey of primary gray bat hibernacula during the winter of 2005-2006. This task consisted of surveys of all accessible primary caves by experienced biologists using consistent methods. This survey documented stable or increasing population levels across the gray bat's range. The only hibernaculum where a population decrease was recorded was Bat Cave, MO. All other caves surveyed showed substantial increases in wintering populations. For example, estimates at Bellamy and Hubbards Caves, TN, and Bonanza Cave, AR, were up 53 percent, 232 percent, and 170 percent, respectively, compared to the most recent surveys in the past several years.

A DOD Legacy project was funded in 2006 to support efforts to recover gray bat populations. Legacy tasks included:

1. Provision of an improved gate/fence for Bellamy Cave, TN
2. Securing protection of Pearson Cave, TN
3. Repair of access steps to Jesse James Cave, KY
4. Surveying selected maternity caves in Tennessee
5. Conducting hibernacula surveys of 9 caves in Missouri, Tennessee, and Arkansas (11 caves were surveyed, including 2 caves in Kentucky)

All tasks have been accomplished. Pearson Cave was purchased from the previous land owner by a private donor working with TNC and will ultimately become the property of the TWRA. These actions should ensure long-term protection and recovery of the gray bat throughout the species' range.

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## Appendix A: List of Gray Bat Caves Throughout the Species' Range

(Information obtained from various sources including the Gray Bat Recovery Plan (U.S. FWS 1982), state survey reports, and U.S. FWS unpublished data.)

Name	County	Colony Type	Priority	Owner	Comments
<b>Alabama</b>					
Anderson Cave	Shelby		2		* PLCA, Sign only
Baker Cave	Colbert		2		* PLCA, Sign only
Bat Cave	Lauderdale		3		* Survey to Determine Needs
Bishop Cave	Marshall	Summer	3		* Survey to Determine Needs
Blowing Springs Cave	Lauderdale	Bachelor	2		* PLCA, Sign only
Cathedral Caverns	Marshall		4		* None
Cave Springs Cave	Morgan	Maternity	1		* Fence, Sign
Collier Cave	Lauderdale	Transient	3		Surveyed, Sign at entrance
Collier-Bone Cave	Lauderdale				
Davis Bat Cave	Lauderdale	Maternity			
Dunham Cave	Marshall		2		* PLCA, Sign Only
Fern Cave	Jackson	Hibernating	1		* PLCA, Sign Only
Flutter Putter Cave	Jackson				
Georgetown Cave	Colbert	Maternity	1		* Modify Fence
Gross Skeleton Cave	Jackson		2		* Sign Only
Guntersville Caverns	Marshall		2		* PLCA, Sign Only
Hambrick Cave	Marshall	Maternity	1		Gated, Fenced
Hering Cave	Madison		3		* Survey to Determine Needs
Hollyberry Cave	Lauderdale	Summer	3		
Honeycomb Cave	Marshall		3		* Survey to Determine Needs

Name	County	Colony Type	Priority	Owner	Comments
Honeycomb Mine	Marshall				
Hope Cave	DeKalb				
Horse Skull Cave	Jackson		3		* Survey to Determine Needs
Hughes Cave	Morgan		3		* Survey to Determine Needs
Indian Cave	Limestone	Maternity	2		* Fence, Sign
Jess Elliot Cave	Jackson				
Key Cave	Lauderdale	Maternity	1		Fenced
King's School Cave	Marshall	Bachelor	2		* Stop Contamination Source
King's Spring Cave	Marshall		3		* Survey to Determine Needs
Ledbetter Cave	Marshall		3		* Survey to Determine Needs
Little Nat Cave	Jackson		3		* Survey to Determine Needs
Lykes Cave	DeKalb		2		* PLCA, Fence
McKinney Cave	Colbert	Summer	3		* Survey to Determine Needs
Nitre Cave	Jackson		2		* PLCA, Sign
Old Blowing Cave	Marshall	Summer	2		* PLCA, Sign Only
Orcestrwells Cave	Jackson		3		* Survey to Determine Needs
Portersville Bat Cave	DeKalb		2		* PLCA. Sign Only
Rock House Cave	Covington				
Sanders Cave	Conecuh	Maternity	1		* PLCA, 1/2 gate
Sauta Cave	Jackson	Maternity	1		* Regular patrol, Maintenance
Section Cave	Jackson				
Shelta Cave	Madison		2		* Replace Gate with Fence
Stanley-Carden Cave	DeKalb		3		* Survey to Determine Needs
Sublett Springs Cave	Madison				
Talucah Cave	Morgan		3		* PLCA
Woody Cave	Morgan		3		* Survey to Determine Needs
<b>Arkansas</b>					
Bonanza Cave	Baxter	Hibernating	1	ONF	Gated by USFS

Name	County	Colony Type	Priority	Owner	Comments
Bald Scrappy Cave	Stone	Transient	2	ONF	* 1/2 Gate
Bennett Cave	Carroll	Transient	2	Private	* PLCA, 1/2 gate
Bergren Cave	Izard	Maternity / Transient	3	Private	Gated
Big Creek Cave	Searcy	Maternity		Private	
Blagg Cave	Sharp	Transient	2	Private	Signed; Abandoned by Maternity Colony
Blanchard Springs Caverns	Stone	Hibernating / Bachelor	2	ONF	Fenced
Bone Cave	Independence	Maternity	1	Private	Fenced
Brewer Cave	Boone	Transient	2	Private	* PLCA, 1/2 gate
Cave Mountain Cave	Newton	Hibernating	2	BNR	Fenced
Cave River Cave	Stone	Maternity	2	Private	* PLCA, 1/2 Gate
Cave Springs Cave	Benton	Maternity	2	ANHC	ANHC - Fenced
Corkscrew Cave	Newton	Hibernating		BNR	
Crane Cave	Searcy	Bachelor	2	BNR	Fenced
Crystal Cave	Benton	Transient / Bachelor	2	Private	Fenced
Diamond Cave	Newton		2		* PLCA
Dodd Cave	Independence	Transient		Private	
Edgman Cave	Newton	Hibernating		TNC	Gated
Elm Cave	Marion	Transient		Private	
Fallout Cave	Searcy	Bachelor	2	BNR	Fenced
Fitton Cave	Newton	Hibernating		BNR	Gated
Flea Cave	Newton	Transient		BNR	
Gustafson Cave	Stone	Hibernating		ONF	Gated
Hankins Cave	Independence	Hibernating	2	Private	* PLCA, Full Gate
Hell Creek Cave	Stone	Abandoned	2	ANHC	Gated
Hidden Spring Cave	Stone	Hibernating		ONF	Fenced
Horseshoe Cave	Newton	Bachelor		BNR	
Horsethief Cave	Madison	Maternity	2	Private	* PLCA, 1/2 gate
Huffman Cave	Marion	Bachelor / Hibernating		Private	
Joe Bright Cave	Stone	Transient / Hibernating	2	Private	* PLCA, 1/2 Gate
John Eddings Cave	Newton	Bachelor		BNR	Fenced
Jones Cave	Lawrence	Transient		Private	
Lands End Cave	Pope	Transient		Private	
Little Bear Cave	Newton	Abandoned	2		Improper cave gate installed
Logan Cave	Benton	Maternity	1	FWS	Gated, fenced

Name	County	Colony Type	Priority	Owner	Comments
Morris Cave	Sharp	Transient		Private	Gated
Newark Storm Sewer	Independence	Maternity		City Owned	
Norfolk Cave	Baxter	Transient		ONF	
Old Joe Cave	Baxter	Maternity	2	Private	Fenced
Optimus Cave	Stone	Transient	2	ONF	* 1/2 Gate
Ozark Acres Cave	Sharp	Transient	2	Private	* PLCA, 1/2 Gate
Peter Cave	Searcy	Bachelor	2	BNR	Fenced
Pigeon Roost Cave	Benton	Transient	2	ADPT	Fenced with artificial entrance
Rory Cave	Stone	Transient	2	Private	* PLCA
Rowland Cave	Stone	Hibernating	2	ONF	Fenced
Shirley Bat Cave	Van Buren	Bachelor		Private	
Silver Valley Mine	Boone	Transient	3	Private	* Maintain
Still Cave	Baxter	Hibernating		ONF	
Summer Cave	Marion	Maternity		BNR	
War Eagle Caverns	Benton	Maternity	2	Private	Gated
Wet Cave	Boone	Bachelor	3	Private	* Survey to Determine Needs
Wolf Creek Cave	Newton	Hibernating	2	ONF	* Fence
<b>Florida</b>					
Bush Cave	Jackson	Maternity?	4		* None
Dugong Cave	Jackson	Hibernating		Private	Intermittently used
Fears Cave	Jackson	Transient?	2		* PLCA, Sign Only
Geromes Cave	Jackson	Transient?	1	Private	Protection signs
Girards Cave	Jackson	Maternity	1	Private	Protected by Landowner
Judges Cave	Jackson	Maternity	1	FFWCC	Fenced and Posted
Old Indian Cave	Jackson	Hibernating	1	FPS	* Fence, remove gates
River Cave	Jackson	?	2	Private	* Signs only
Sneads Bat Cave	Jackson	Maternity?	2	Private	* PLCA, Sign Only
<b>Georgia</b>					
Beatoms Cave	Polk		3		* Survey to Determine Needs
Chickamauga Cave	Cortoosa	Maternity		Private	Not protected; gate being considered
Fricks Cave	Walker	Bachelor		SE Cave Conservancy	Protected
Lowry Cave	Chattooga	Bachelor		Temple Inland Timber Co.	Inaccessible; behind locked gate

Name	County	Colony Type	Priority	Owner	Comments
White River Cave	Polk		3		* Survey to Determine Needs
<b>Illinois</b>					
Cave Spring Cave	Hardin	Maternity	1		* PLCA, Gate
Twin Culvert Cave	Pike		4		* None
<b>Kansas</b>					
Storm Sewer	Crawford	Maternity	2		* None
<b>Kentucky</b>					
Babe Allen Cave	Logan	Bachelor	4	Private	No protection
Belt Cave	Hardin	Transient	4	Private	Wooden gate
Big Sulphur (Springs) Cave	Trigg	Summer	2	Private	No protection
Blowing Cave	Pulaski	Maternity	2	Private	No protection
Boones Cave	Taylor	Maternity	1	Private	Sign
Bryant Edmunds Cave	Barren	Maternity	2	Private	Sign
Buckner Spring Cave	Hart	Summer?	3	Private	Survey to assess use.
Burgess Cave	Nelson	Maternity	2	Private	Sign
Buzzard Cave	Breckinridge	Transient/Hibernating	4	Private	Sign
Buzzard Roost Cave	Monroe	Maternity	1	Private	Sign; this colony appears to use Robertson Cave also.
Campbell's Cave	Christian	Former Summer	3	Private?	No protection
Caney Branch Cave	Clinton	Maternity	1	Private	Sign
Carpenter (Holland) Cave	Allen	Maternity	1	Private	Sign, Alarm, Conservation Easement
Chrisman's Cave	Jessamine	Maternity	3	Private	No protection
Coach Cave	Edmonson	Hibernating	1	Private	Gated
Colossal Cave	Edmonson	Hibernating	4	NPS (MCNP)	Gated
Cool Springs Cave	Trigg	Maternity	1	Private	Signs
Cravens Cave	Christian	Bachelor	4	Private	Fenced
Crump (Cave Spring Caverns)	Warren	Summer/Transient	4	Private	Gated
Daniel Boone's Cave	Jessamine	Former Maternity	3	Private	Gated (chute-style gate)
Dixon Cave	Edmonson	Hibernating	4	NPS (MCNP)	Gated
Friendship Cave	Warren	Maternity	4	Private	No protection



Name	County	Colony Type	Priority	Owner	Comments
Garbage Pit (Sloans Valley) Cave	Pulaski	Former Maternity	3	Private	Wooden door & plastic blocking entrance.
Grahampton Cave	Meade	Summer/Transient	3	DOD (Fort Knox)	Fenced
Glass Farm Cave	Franklin	Maternity	3	Private	Fenced
Hermit Cave	Jessamine	Former Summer/Transient?	4	Private	No protection
Hickman Creek/1268 Bridge	Jessamine	Maternity	4?	KYTC	No protection
Ison Cave	Garrard	Summer	2	Private	No protection
Jesse James Cave	Edmonson	Hibernating	1	Private	Gated
Jones Cave	Adair	Maternity	1	KDFWR	Sign
Limestone Cave	Whitley	Summer/Transient?	4	Private	No protection
Long Cave	Edmonson	Hibernating/Formal Summer	3	NPS (MCNP)	Gated
Mammoth Cave (Rafinesque Hall)	Edmonson	Former Summer?	3	NPS (MCNP)	Gated but toured
Mill Bluff Cave	Caldwell	Transient?	3	Private	Survey to better assess use.
Minton Hollow (Sloans Valley)	Pulaski	Former Hibernating?	3	NPS (MCNP)	Section of cave protected with sign/fence
Morgan's Cave	Meade	Transient	4	Louisville Metro Parks	Otter Creek Park; gated
Mutters Cave	Barren	Maternity	1	KSNPC	Sign
Overstreet Cave	Jessamine	Maternity	1	Jessamine Co. Parks/Rec	No protection
Payne (Temple Hill Saltpeter) Cave	Barren	Maternity	1	Private	Signs
Penitentiary Cave	Breckinridge	Transient	4	Private	Sign
Phil Goodrum Cave	Allen	Maternity	1	KSNPC	Sign
Pruitt Saltpeter Cave	Warren	Summer	4	Private	No protection
Railroad Tunnel (Sloans Valley)	Pulaski	Former Summer/Transient?	3	Private	No protection
Robertson Cave	Monroe	Maternity	1	Private	Sign; appears to be used by Buzzard Roost colony.G137
Riders Mill Cave	Hart	Maternity	1	Private	Signs

Name	County	Colony Type	Priority	Owner	Comments
Smoky Cave	Simpson	Maternity	1	Private	Gated - one entrance only
Son of Finney Cave	Warren	Maternity	2	Private	Sign
Sulphur Creek Cave	Metcalfe	Maternity	1	Private	Sign
Tar Kiln Cave	Elliott	Former Summer	3	Private	No protection
Todds Cave	Adair	Former Summer	4	Private	No protection
Watt Cave	Warren	Maternity	1	Private	Sign
Wax Jr. Cave	Grayson	Maternity	2	USACE	Sign
Woodard Cave	Green	Summer/Transient?	3	Private	Survey to assess use.
<b>Missouri</b>					
Adkins Cave	Camden	Maternity	2	Private	Sign
Arthur Cave	Barry	Maternity		Private	No protection
Bagnell Dam Culvert	Camden	Maternity		Private	No protection
Bat Cave	Crawford	Maternity	3	MDC	No protection
Bat Cave	Dent	Maternity	1	Private	Sign
Bat Cave	Laclede	Maternity	2	Private	No protection
Bat Cave	Miller	Maternity	2	MDC	Sign
Bat Cave	Oregon	Maternity	2	USFS	Sign
Bat Cave	Ozark	Maternity	2	USFS	Gated
Bat Cave	Shannon	Hibernating	2	TNC / NPS	Fenced
Bat Cave	Texas	Maternity	3	Private	Sign
Bat Cave No. 1	Franklin	Maternity	4	Private	Gated
Bat Cave No. 1	Hickory	Maternity	4	USACE	No protection
Bat Cave No. 1	Pulaski	Maternity	2	Private	No protection
Bat Cave No. 2	Franklin	Maternity	2	Private	Sign
Bat Cave No. 2	Hickory	Transient	4	USACE	No protection
Bat Cave No. 2	Pulaski	Maternity	2	Private	No protection
Bat Cave No. 3	Franklin	Maternity	3	Private	Sign
Beck Cave	Hickory	Maternity	1	USACE	Fenced
Beer's Lake Cave	St. Clair	Unknown		Private	No protection
Big Mouth Cave	Oregon	Transient	2	Private	Sign
Blacksmith Cave	Barry	Maternity		Private	Sign
Blackwell Cave	Hickory	Maternity	2	USACE	Gated
Bob and Mark No. 1 Cave	Ozark	Maternity		Private	No protection
Bob and Mark No. 2 Cave	Ozark	Maternity		Private	No protection
Boiling Spring Cave	Pulaski	Unknown		Private	Disturbed; gate proposed

Name	County	Colony Type	Priority	Owner	Comments
Boone Cave	Boone	Maternity	2	Private	No protection
Brown Cave No. 1	Pulaski	Maternity	3	Private	Sign
Brown Cave No. 2	Pulaski	Transient	3	Private	No protection
Bruce Cave	Pulaski	Maternity	4	Private	No protection
Bunch Cave	Camden	Maternity	4	Private	No protection
Carroll Cave	Camden	Maternity	2	Private	Gated
Cat Hollow Cave	Dallas	Transient	2	Private	Sign
Chimney Cave	Shannon	Hibernating	1	NPS	No protection
Cleveland Cave	St. Clair	Unknown		Private	No protection
Coalbank Cave	Carter	Maternity	2	NPS	Fenced
Coffin Cave	Laclede	Hibernating	1		
Cole Camp Cave	Benton	Transient	3	Private	No protection
Competition Bat Cave	Laclede	Maternity		Private	Sign
Cooks Cave	Reynolds	Maternity	2	Private	Sign
Cookstove Cave	Shannon	Transient		Private	No protection
Coolbrook Cave	Jasper	Maternity	2	Private	Sign
Davis Cave No. 2	Laclede	Transient	4	Private	No protection
Davis Cave No. 3	Laclede	Maternity		Private	No protection
Dead Man	Oregon	Maternity		USFS	Sign
Devil's Icebox Cave	Boone	Maternity	2	MDNR	Sign
Dobkin Spring Cave	Crawford	Transient		Private	No protection
Donovan Cave	Texas	Transient		Private	Sign
Dry Branch Cave	Morgan	Transient	2	Private	Sign
Elkton Cave	Hickory	Unknown		Private	No protection
Empire Electric Dam	Taney	Transient		Private	Access Limited
Estes Cave	Benton	Maternity	2	Private	Sign
Fiery Forks Cave	Camden	Transient	2	Private	Sign
Fisher Cave	Franklin	Maternity	2	MDNR	Gated
Fisher Cave	Ralls	Maternity	2	Private	No protection
Flippin Cave	Benton	Transient	3	Private	Sign
Frankford Cave	Pike	Maternity	2	Private	No protection
Freeman Cave	Pulaski	Transient	2	Private	No protection
Grandpa Chipley's Cave	Camden	Maternity	2	Private	Sign
Great Scott Cave	Washington	Transient	2	MDC	Gated
Great Spirit Cave	Pulaski	Maternity		MDC	Fenced

Name	County	Colony Type	Priority	Owner	Comments
Hannah Cave	Camden	Transient	2	Private	No protection
Henson Cave	McDonald	Transient	3	Private	No protection
Hilderbrand Cave	Dallas	Maternity	2	Private	Sign
Holton Cave	Boone	Maternity	2	Private	Sign
Hunter's Cave	Boone	Transient	2	MDC	Gated
Inca Cave	Pulaski		1		* Fence, Sign
Indian Ford Cave	Maries	Maternity	2	Private	No protection
Jesse James Cave	McDonald	Unknown		Private	No protection
Jones Cave	Pulaski	Unknown		Private	No protection
Kinsley Quarry Cave	Henry	Transient	4	Private	No protection
Lewis and Clark Cave	Boone	Transient	2	Private	Sign
Lime Kiln Cave	St. Clair		4		* None
Lone Hill Onyx Cave	Franklin	Transient	3	MDC	No protection
Low Water Bridge Cave	Greene	Maternity	3	Private	No protection
Lower Burnt Mill Cave	Camden	Maternity	2	Private	Sign
Martin Cave No. 2	Shannon	Transient	2	Private	No protection
Marvel Cave	Stone	Hibernating	1	Private	Gated
Mary Lawson Cave	Laclede	Maternity	2	Private	Fenced
Mauss Cave	Camden	Maternity	1	Private	Sign
Mayfield Cave	Laclede	Maternity	2	USFS	No protection
Maze Cave	Dade	Maternity	2	Private	Sign
McDowell Cave	Miller	Transient	2	MDNR	Sign
McKee Cave	Dallas	Transient	2	Private	Sign
Medlock Cave	Shannon	Transient		Private	No protection
Moles Cave	Camden	Maternity	1	MDC	Sign
Mose Prater Cave	Shannon	Hibernating			
Mud Cave	Stone	Unknown		Private	No protection
Nill Cave	Shannon	Transient		NPS	Sign
No Name Cave	McDonald	Maternity		Private	No protection
Onondaga Cave	Crawford	Maternity	4	MDNR	
Onyx Cave	Crawford	Transient	2	MDC	Gated
Onyx Cave	Pulaski	Transient		Private	No protection

Name	County	Colony Type	Priority	Owner	Comments
Panther Springs Cave	Carter	Transient		Private	No protection
Pine Hill Cave	Ozark	Unknown		Private	No protection
Piquet Cave	Pulaski	Maternity	2	Private	Sign
Pleasant Valley Cave	Jefferson	Maternity	3	Private	No protection
Powder Mill Cave	Shannon	Transient		NPS	Gated
Prairie Hollow Cave	Camden	Transient	2	Private	Sign
Radcliffe Cave	Laclede	Maternity		Private	No protection
Rantz Cave	Christian	Maternity	2	Private	Sign
River Cave	Camden	Maternity	2	MDNR	Gated
River Cave	Osage	Maternity	3	Private	No protection
Roaring Spring Cave	Franklin	Maternity	1	MDC Lease	Sign
Round Spring Cave	Shannon	Transient	2	NPS	Gated
Ruark Cave No. 2	Lawrence	Maternity		Private	No protection
Ruark Cave No. 3	Lawrence	Unknown	3	Private	No protection
Russell Cave	Ozark	Unknown		Private	Sign
Saloon Cave	Crawford	Maternity	2	MDC	Fenced
Saltpeter Cave	Dallas	Unknown	3	Private	No protection
Saltpeter Cave	Pulaski	Unknown		Private	Sign
Saltpeter Cave	Stone	Maternity	1	Private	Sign
Sequiota Cave	Greene	Unknown		SPF Pks	No protection
Shamel Cave	Laclede	Maternity	2	Private	Sign
Slough Bottom Hollow Cave	Ozark	Maternity		USACE?	No protection
Smittle Cave	Wright	Maternity	2	MDC	Fenced
Stillhouse Cave	Stone	Maternity	3	Private	Sign
Thrasher Ford Cave	Oregon	Maternity		USFS	Sign
Tumbling Creek Cave	Taney	Maternity	1	Private	No protection
Tunnel Cave	Pulaski	Maternity	2	Private	Sign
Turnback Cave	Lawrence	Transient		MDC	Fenced
Turner Mill Spring Cave	Oregon	Maternity		USFS	Gated
Twenty-three Degree Cave	Crawford	Transient	2	Private	Sign
Twin Springs Cave	Franklin	Transient	2	Private	Sign

Name	County	Colony Type	Priority	Owner	Comments
Unnamed Cave No. 8	Laclede	Unknown	3	Private	No protection
Unnamed No. 2 Cave	Cole	Maternity	2	Private	Sign
Wicks Cave	Reynolds	Transient		Private	No protection
Wind Cave	Shannon	Transient	4	Private	Sign
Windy Cave	Pulaski	Transient	2	Private	No protection
<b>Oklahoma</b>					
Adair Bat Cave	Adair		3		* MNTN, Gate, Lock, Restr Traff
Charley Owl Cave	Adair		2		* Gate
Etta Cave	Cherokee		4		* None
Linda Bear Paw Cave	Delaware		2		* PLCA, Sign Only
Roberts Cave	Delaware		3		* PLCA, Sign Only
Spavinaw Bat Cave	Delaware		2		* Signs, Restrict Research
Stansberry's Cave	Delaware		1		* PLCA, Sign, Gated
Talbort Cave	Delaware		3		* PLCA
Three Forks Cave ( 4 )	Adair		3		* PLCA, Sign Only
Twin Cave	Delaware		3		* Fence or Regate, Sign
<b>Tennessee</b>					
Alexander Cave	Perry	Maternity	2	TNC	Gated
Ament Cave	Putnam	Maternity	2	City of Cookeville	* PLCA, Sign Only
Arch Cave	Green	?	3		* Survey to Determine Needs
Baker Cave	White		4		* None
Baloney Cave	Knox	Transient	2	Private	* PLCA, Fence, Sign
Bat Cave	Hickman	Maternity	2	Private	* Coop Agree, Sign Only
Bat Cave	Lincoln	Maternity	2	Private	* PLCA, Sign Only
Baugus Cave	Decatur	?	3		* Survey to Determine Needs
Bellamy Cave	Montgomery	Maternity/Hibernating	1	TNC	Fenced and Gated
Benderman Cave	Maury	Bachelor	2	Private	* PLCA
Blowing Cave #1	Perry	Summer	3		* Survey to Determine Needs
Blowing Hole Cave	Knox		4		* None
Blythe Ferry Cave	Meigs	Bachelor	2	TVA	* Fence, Sign

Name	County	Colony Type	Priority	Owner	Comments
Bridgewater Cave	Smith	Maternity/Bachelor	2		* PLCA
Bristol Storm Drain	Sullivan	Maternity		City of Bristol	
Caney Hollow Cave	Franklin	Maternity	2	Private	* PLCA, Sign Only
Cedar Creek Cave	Greene		4		* None
Coleman Cave	Montgomery	Maternity	3	Private	* Survey to Determine Needs
Coon Cave	Grainger		4		* None
Cripps Mill Cave	DeKalb	Maternity	1	Private	* PLCA, Sign Only
Dry Cave	Robertson	Summer	3		* Survey to Determine Needs
Dud's Cave	Jackson	Maternity	2	USACE, Nashville Dist.	Gated
Espy Cave	Cannon	Summer			
Eves Cave	Meigs	Bachelor	2	TVA ?	* Sign Only
Featherfoot Cave	Decatur	Maternity	2	TVA	Fenced
Gallatin Cave	Wilson	Summer	3	USACE, Old Hickory Reservoir	* Survey to Determine Needs
Grassy Creek Cave	Rhea	Maternity	2	Quarry Company	* PLCA, Sign Only
Haile Cave	Jackson	Maternity	3	USACE, Nashville Dist.	* Survey to Determine Needs
Harris Cave	Rhea	Maternity	2	Private	* PLCA, Sign Only
Haskell Sims Cave	White		4		* None
Herron Cave	Rutherford	Bachelor	2	Private	Gated
Horner Cave	Hawkins	Transient	2		* PLCA
Hound Dog Drop Cave	Wayne	Summer/Bachelor		Southeastern Cave Conser., Inc.	CMA with TNC in Progress
Hubbards Cave	Warren	Hibernating	1	TNC	Gated
Ice Cave	Wayne	Summer	3		* Survey to Determine Needs
Indian Cave	Grainger	Maternity	1	Private	* PLCA, 1/2 Gate
Jack Daniel Cave	Moore		4		* None
John Fisher Cave	Smith		4		* None
Knowles Ridge Cave	Warren	Summer/Bachelor		Private	
Lost Creek Cave	Union	Summer	2	TWRA	* Fence
Markham Cave	Clay	Bachelor	2	Private	* PLCA, Sign Only

Name	County	Colony Type	Priority	Owner	Comments
Meredith Cave	Campbell	Transient	3	Private	* PLCA, Modify Gate
Morrell Cave	Sullivan	Summer	3	Private	* Survey to Determine Needs
Mud Flats Cave	Knox		4		* None
Neptune Saltpeter Cave	Cheatham		4		* None
New Piper Cave	Smith	Summer	3		* Survey to Determine Needs
Nickajack Cave	Marion	Maternity	1	TVA	Fenced
Norris Dam Cave	Campbell	Maternity	2	TVA	New Fence Installed
Oaks Cave	Union	Maternity	1	TWRA	Monitored by TWRA
Only Saltpeter Cave	Hickman	Transient	3		* Survey to Determine Needs
Patton Cave	Bledsoe		4		* PLCA, Sign Only
Pearson Cave	Hawkins	Hibernating/Bachelor	1	TNC	Gated
Pennington Cave	Franklin	Summer	3	TVA	* Survey to Determine Needs
Piper Cave	Smith	Maternity	2	Private	* PLCA, Fence
Rattling Pit Cave	Cocke	Hibernating/Bachelor	3	City of Newport (Water Dept.)	* Survey to Determine Needs
Robinson Cave	Overton	Summer	3		* Survey to Determine Needs
Rockhouse Cave	Hancock		4		* None
Rose Cave	White	Maternity/Summer	4	TWRA	* None
Sensabaugh Cave	Meigs	Bachelor	2		* PLCA, Sign Only
Shipman Creek Cave	Bedford		2		* PLCA
Short Creek Cave	Perry	Transient	3		* Survey to Determine Needs
Station Creek Cave	Claiborne	Summer	3		* Survey to Determine Needs
Swallow Bluff Cave	Decatur	Summer	3		* Survey to Determine Needs
Tobaccoport Cave	Stewart	Hibernating/Bachelor	1	Private	Gated
Trussel Cave	Grady	Maternity	2		* PLCA, Sign Only
Unnamed cave	Greene	Maternity		Private	
Ward Cave	White	Summer	3		* Survey to Determine Needs
White Buis Cave	Claiborne	Maternity	1	Private	* PLCA, Sign Only
Wilmoth Cave	Sequatchie		4		* None
Woods Dam	Franklin	Maternity	2	USDOD Arnold Eng. Dev. Center	* Coop. Agreement



Name	County	Colony Type	Priority	Owner	Comments
Yell Cave	Bedford	Maternity		Private	
<b>Virginia</b>					
Clinchport Cave	Scott		2		* PLCA, Sign Only
Gibson-Frazier Cave	Lee		4		* None
Litton Cave # 1	Lee		4		* None
Morrell Cave	Lee		4		* None
Tritt Cave	Lee		4		* None
Grigsby Cave	Scott		4		* None
<p>* Information from Gray Bat Recovery Plan (U.S. FWS 1982)</p> <p>PLCA = Purchase, Lease, or Cooperative Agreement</p> <p>ADPT = Arkansas Department of Parks and Tourism</p> <p>ANHC = Arkansas Natural Heritage Commission</p> <p>BNR = Buffalo National River</p> <p>CMA = Cooperative Management Agreement</p> <p>DOD = Department of Defense</p> <p>FFWCC = Florida Fish and Wildlife Conservation Commission</p> <p>FPS = Florida Park Service</p> <p>FWS = U.S. Fish and Wildlife Service</p> <p>KDFWR = Kentucky Department of Fish and Wildlife Resources</p> <p>KYTC = Kentucky Transportation Cabinet</p> <p>MCNP = Mammoth Cave National Park</p> <p>MDC = Missouri Department of Conservation</p> <p>MDNR = Missouri Department of Natural Resources</p> <p>NPS = National Park Service</p> <p>ONF = Ozark National Forest</p> <p>TNC = The Nature Conservancy</p> <p>TVA = Tennessee Valley Authority</p> <p>TWRA = Tennessee Wildlife Resource Agency</p> <p>USACE = U.S. Army Corps of Engineers</p> <p>USFS = U.S. Forest Service</p>					

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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13. SUPPLEMENTARY NOTES					
14. ABSTRACT The gray bat ( <i>Myotis grisescens</i> ) is a federally listed endangered species known to occur on several U.S. Army installations in the eastern United States. Seven Army installations and one Air Force base have documented gray bat populations, and these facilities have undertaken programs to protect roosting and foraging sites important to the species. This report reviews the status of the gray bat throughout its range and assesses the population status of gray bats at major hibernacula in Arkansas, Missouri, Kentucky, and Tennessee. Survey records obtained from state agencies showed that in recent years gray bat populations have increased significantly in most primary summer and winter caves. In 2005 the Army cooperated with the U.S. Fish and Wildlife Service and other state and Federal agencies to undertake a range-wide survey of primary gray bat hibernacula. Hibernacula surveys were conducted from December 2005 – January 2007 in 11 caves considered to be critical wintering sites. Results of the survey showed stable to increasing population levels across the species' range. Additionally, a Department of Defense Legacy project was implemented to support conservation efforts to assist with recovery of the gray bat. The project funded improvements and protection of several cave sites in Tennessee and Kentucky, hibernacula surveys of selected caves, and summer surveys of maternity caves in Tennessee. The Army Threatened and Endangered Species Research Program also provided support for these tasks. The current range-wide population of the gray bat is estimated at approximately 3.4 million bats.					
15. SUBJECT TERMS Gray bat ( <i>Myotis grisescens</i> ) Endangered species				Population status Hibernacula surveys Winter populations	
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